ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer

Land Remote Sensing Data Access Workshop
March 13-14, 2012

U.S. Department of the Interior
U.S. Geological Survey

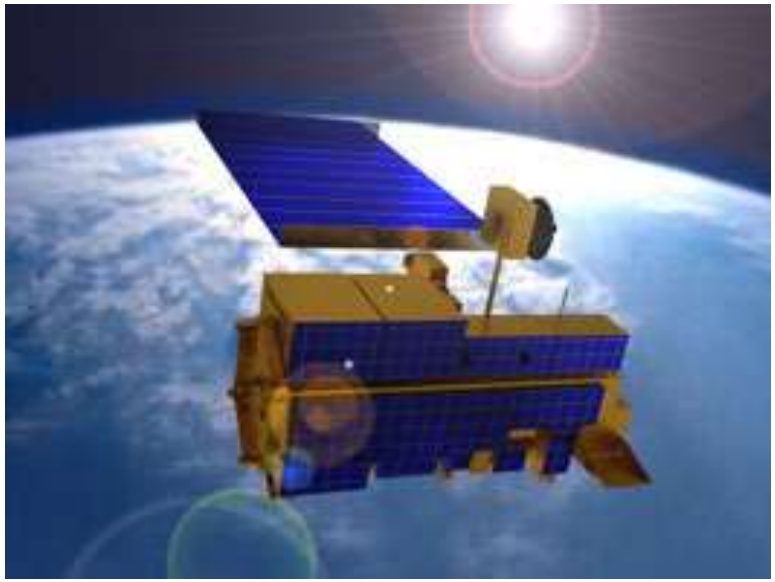
Overview

- ASTER Mission and Instruments
- What Makes ASTER Unique?
- ASTER Data Products and Applications
- Additional Resources

USGS

NASA

ASTER Mission



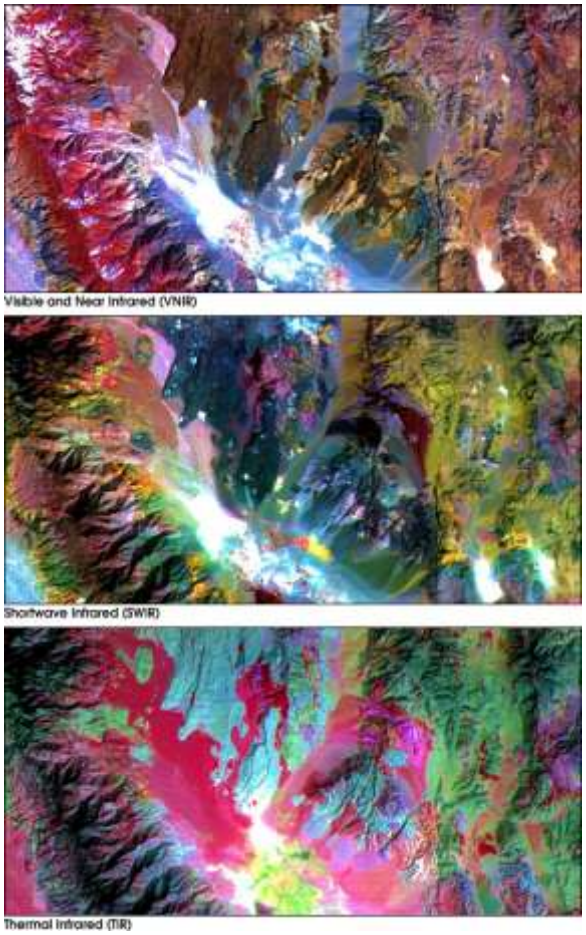
Terra spacecraft. Courtesy: NASA.

- **ASTER flies aboard Terra, the flagship satellite of NASA's Earth Science Missions.**
- **Terra was the first EOS (Earth Observing System) platform and collects science data on a global basis.**
- **Launch Date: December 18, 1999.**

USGS

NASA

ASTER Mission



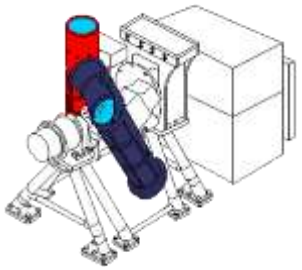
Courtesy: NASA.

- **ASTER is a joint endeavor by the Japanese Ministry of Economy, Trade, and Industry (METI) and NASA, plus university and corporate affiliates.**
- **ASTER obtains detailed global observations of radiance, reflectance, temperature, emissivity, and elevation.**
- **ASTER provides data for many applications, including:**
  - **geology and soils**
  - **urban studies**
  - **vegetation and ecosystem dynamics**
  - **volcano and hazards monitoring**
  - **hydrology**
  - **land change**

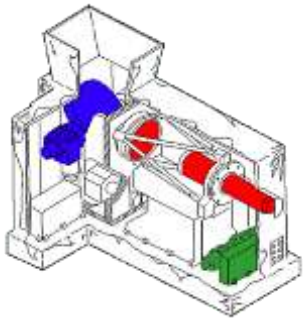
USGS

NASA

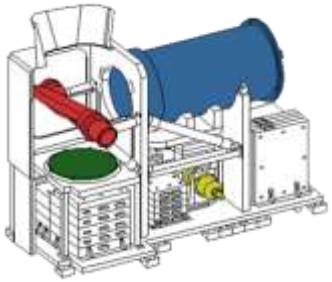
ASTER Instruments



- 3 bands Visible & Near-infrared (VNIR)
- 15m spatial resolution



- 6 bands Shortwave Infrared (SWIR)
- 30m spatial resolution



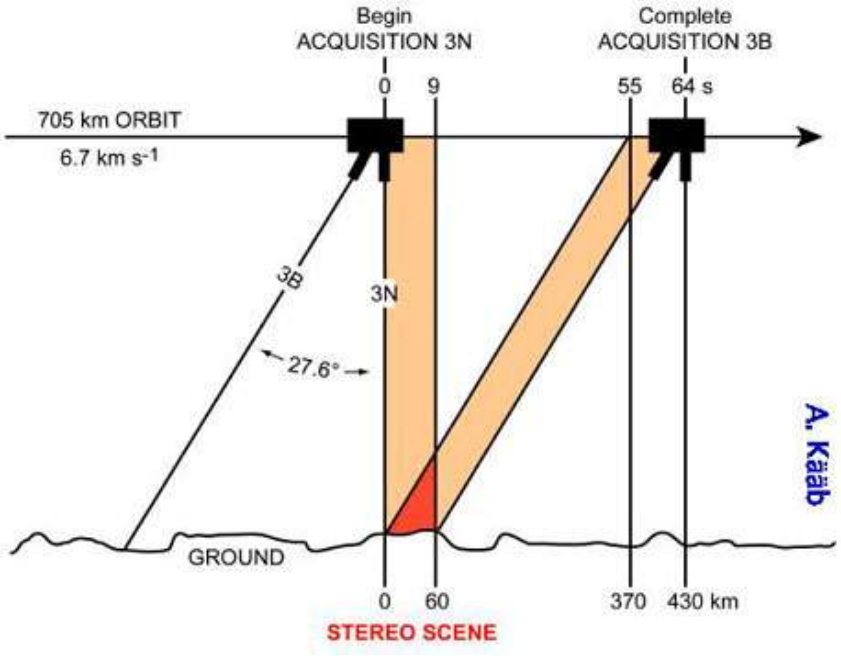
- 5 bands Thermal Infrared (TIR)
- 90m spatial resolution

USGS

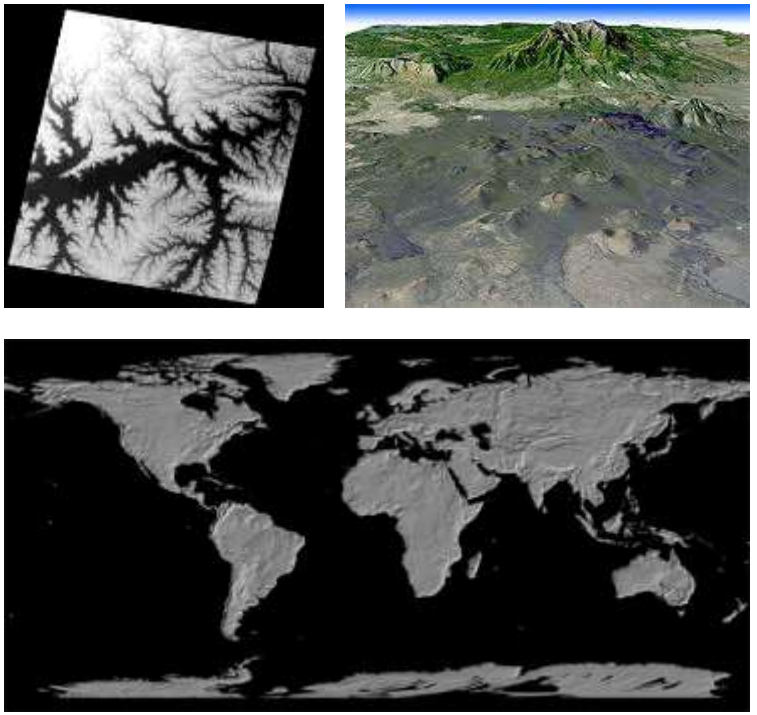
NASA

What Makes ASTER Unique?

Stereo Vision in the Near-infrared



Courtesy: Global Land Ice Measurements from Space (GLIMS Switzerland).
http://www.geo.unizh.ch/~kaeaeb/glims/glims.html



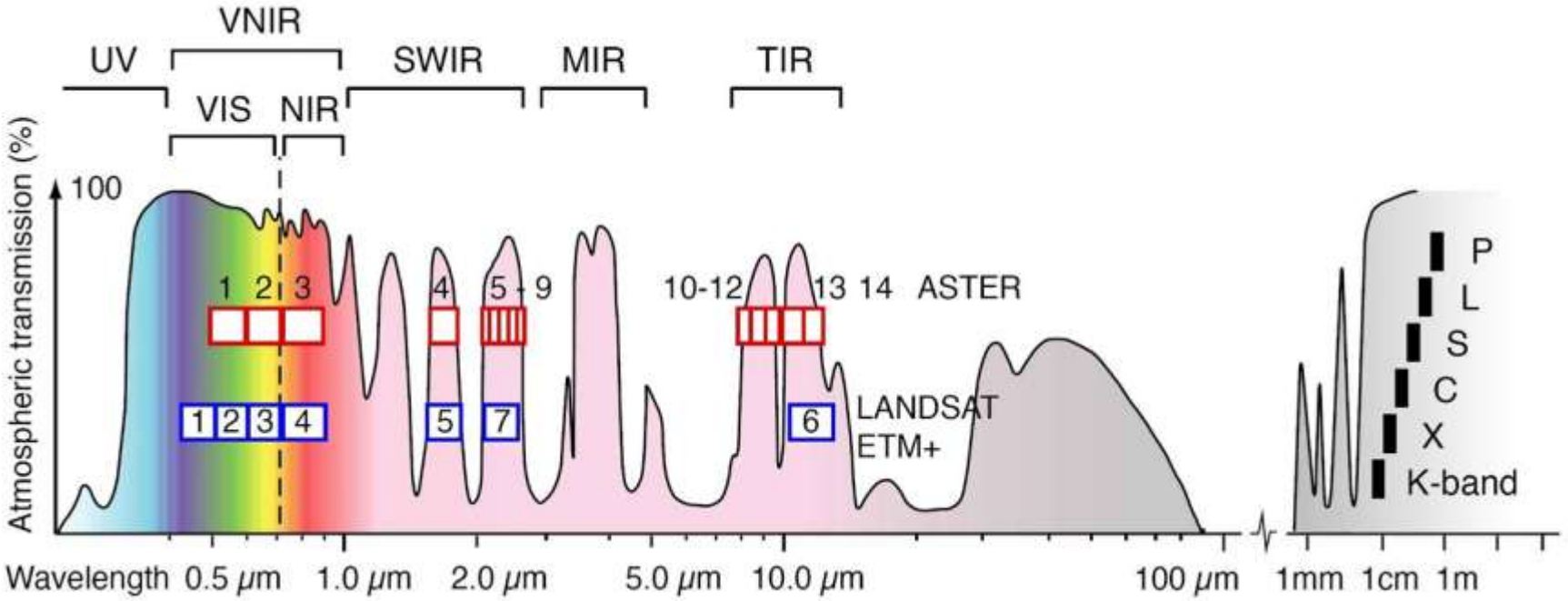
Courtesy: NASA & USGS.

USGS

NASA

What Makes ASTER Unique?

Enhanced Spectral Resolution



Four to six times finer spectral discrimination than Landsat in SWIR & TIR

USGS

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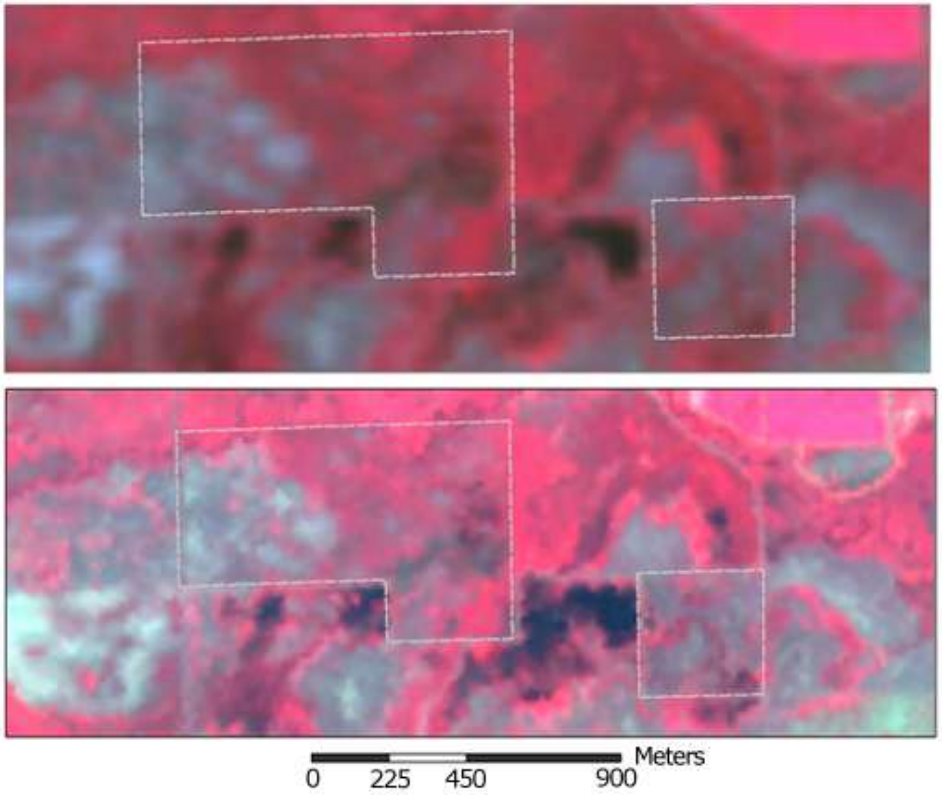
What Makes ASTER Unique?

Enhanced Spatial Resolution (15-meter VNIR)



Landsat 5 VNIR composite (30-meter)

Four times finer spatial discrimination than Landsat in VNIR

ASTER VNIR composite (15-meter)

Adapted from: Comparative Assessment of Multiplatform and Multistage Remote Sensing for Rural Habitat Assessment Initiatives. Central Washington University.

USGS

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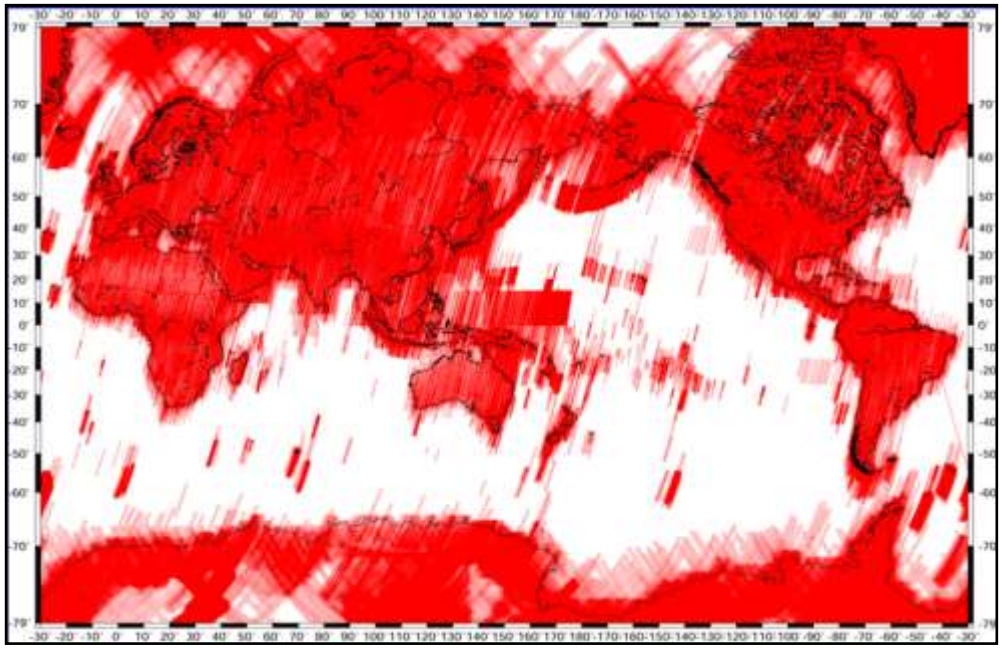
What Makes ASTER Unique?

Acquisition and Coverage



- **Global**
- **Pointable**
- **Taskable**
- **Expedited**
- **12+ years**
- **2+ million scenes**
- **+ 500 scenes/day**

Spatial and temporal coverage vary

USGS

NASA

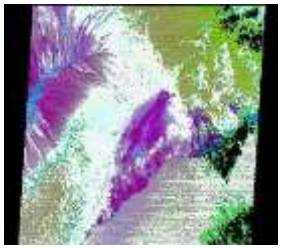
ASTER Data Products - Overview

Level-1 (L1)

AST_L1A
Radiance at-sensor

AST_L1B
Calibrated & registered radiance at-sensor

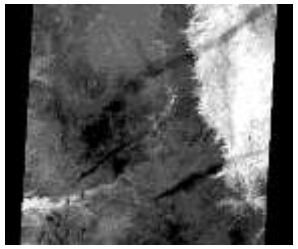
Level-2 (L2)



AST_05
Surface emissivity

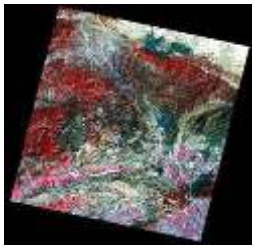
AST_07
Surface reflectance

AST_09
Surface radiance

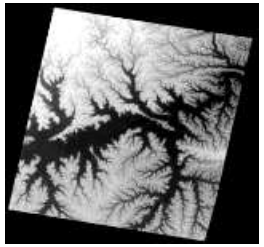


AST_08
Surface temperature

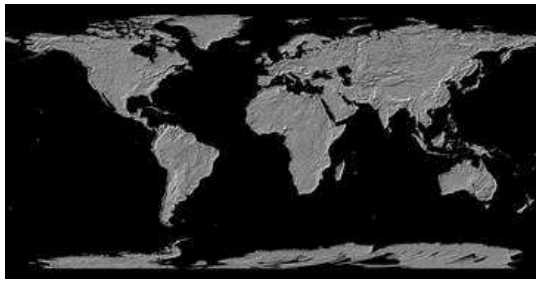
Level-3 (L3)



AST_14
Ortho radiance at-sensor



AST_14DEM
Ortho digital elevation



AST_GTM
Global digital elevation model

USGS

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ASTER Data Products – Suite (n=16)

Shortname	Level	ASTER Product Name	Nominal Resolution (m)	Data Type
AST_L1A	1A	Reconstructed Unprocessed Instrument Data	15, 30, 90	Scene
AST_L1AE	1A	Reconstructed Unprocessed Instrument Data - Expedited	15, 30, 90	Scene
AST_L1BE	1B	Registered Radiance at the Sensor - Expedited	15, 30, 90	Scene
AST_L1B	1B	Registered Radiance at the Sensor	15, 30, 90	Scene
AST_05	2	Surface Emissivity	90	Scene
AST_07	2	Surface Reflectance - VNIR & SWIR	15, 30	Scene
AST_07XT	2	Surface Reflectance - VNIR & Crosstalk Corrected SWIR	15, 30	Scene
AST_08	2	Surface Kinetic Temperature	90	Scene
AST_09	2	Surface Radiance - VNIR & SWIR	15, 30	Scene
AST_09XT	2	Surface Radiance - VNIR & Crosstalk Corrected SWIR	15, 30	Scene
AST_09T	2	Surface Radiance TIR	90	Scene
ASTGTM	3	ASTER Global Digital Elevation Model	30 grid	Tile
AST14DEM	3	Digital Elevation Model	30	Scene
AST14OTH	3	Registered Radiance at the Sensor - Orthorectified	15, 30, 90	Scene
AST14DMO	3	Digital Elevation Model & Registered Radiance at the Sensor - Orthorectified	15, 30, 90	Scene
NAALSED	3	North American ASTER Land Surface Emissivity Database	100	Tile

- *Free (for L1B, U.S. & Territories collection only)*

  All else $60 for approved Federal Users

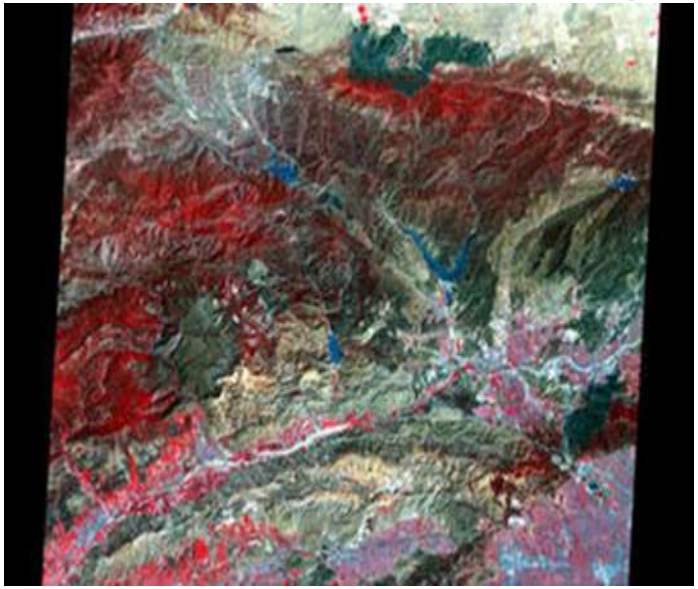
Scene dimensions: 60 x 60 km; Tile dimensions: 1 x 1 degree

USGS

NASA

ASTER Data Products - L1B Detail

L1B On Demand Registered Radiance at the Sensor



Radiometrically calibrated and geometrically co-registered data for the acquired channels of the three different telescopes of Level-1A data.

Data Set Characteristics

Area	~60 km x 60 km
Image Dimensions - VNIR	4200 rows x 4980 columns
Image Dimensions - VNIR (3B)	4600 rows x 4980 columns
Image Dimensions - SWIR	2100 rows x 2490 columns
Image Dimensions - TIR	700 rows x 830 columns
File Size Total	118 MB
File Size - VNIR (1, 2, 3N)	~60 MB
File Size - VNIR (3B)	~22 MB
File Size - SWIR (4 through 9)	~30 MB
File Size - TIR (10 through 14)	~6 MB
Spatial Resolution - VNIR	15 m
Spatial Resolution - SWIR	30 m
Spatial Resolution - TIR	90 m
Projection	Universal Transverse Mercator (UTM)
Data Format	HDF-EOS or GeoTIFF
Vgroup Data Fields	15

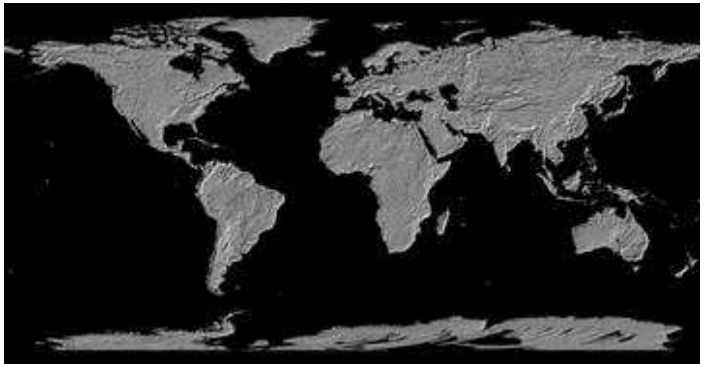
- Freely available over U.S. & Territories

USGS

NASA

ASTER Data Products – ASTGTM Detail

ASTGTM Routine ASTER Global Digital Elevation Model



Global Digital Elevation Model (GDEM), 1 x 1 degree tiles, 30m postings, GeoTIFF format. Cloud-screened DEMS are stacked and residual bad values and outliers are removed. Selected data are averaged to create final pixel values, and residual anomalies are corrected before partitioning the data into 1˚ x 1˚ tiles.

Data Set Characteristics

Tile Size	3601 x 3601 (1 degree by 1 degree)
Pixel Size	1 arc-second
Geographic coordinates	Geographic latitude and longitude
DEM output format	GeoTIFF, signed 16 bits in units of vertical meters
Geoid reference	WGS84/EGM96
Special DN values	-9999 for void pixels, and 0 for sea water body
Tile volume	25 MB uncompressed, 4–5 MB compressed
Coverage	North 83 degrees to south 83 degrees, 22,702 tiles

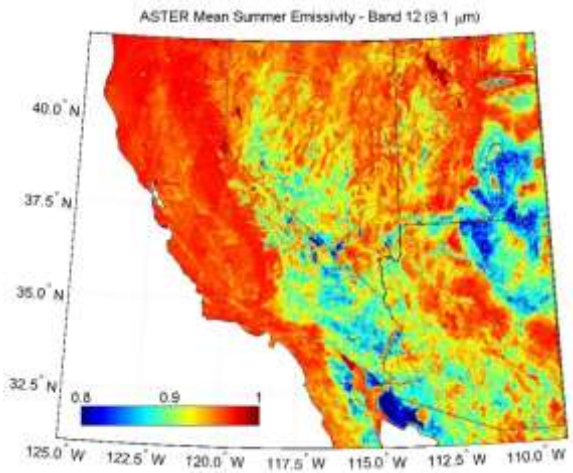
- Improved version 2 released October 2011
- Freely available; redistribution restricted

USGS

NASA

ASTER Data Products – NAALSED Detail

North American ASTER Land Surface Emissivity Database (NAALSED)



Nineteen data layers including summer seasonal (July-September) mean and SD of land surface emissivity, temperature, and top of atmosphere NDVI.

Data Set Characteristics

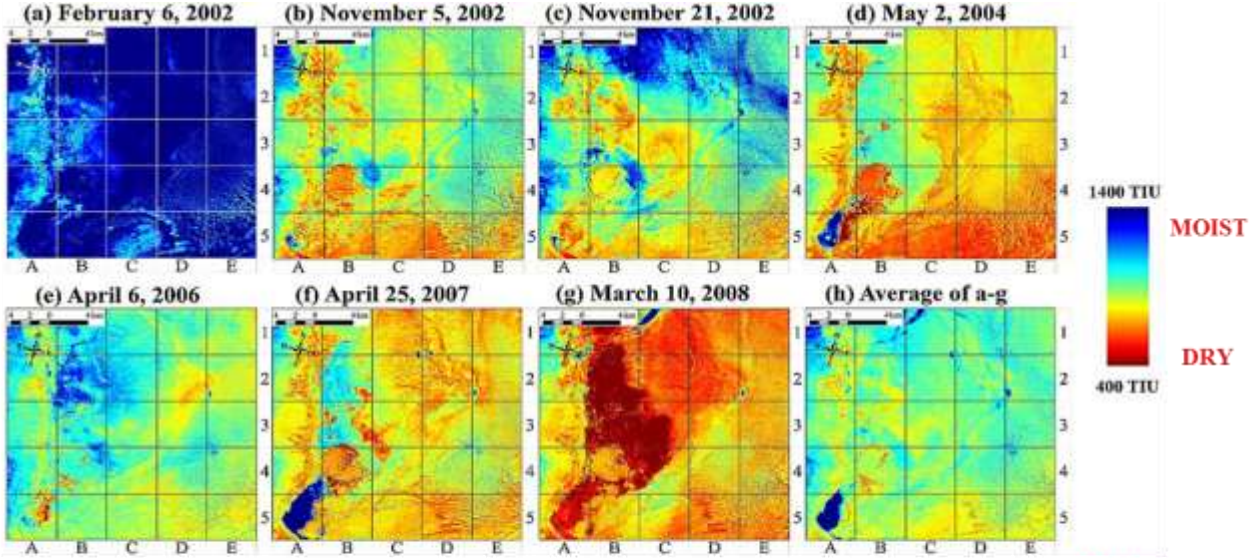
Tile Size	1 degree (°) x 1°
Pixel Resolution	100-meters
Mapping Grid	Geographic latitude and longitude
File Format	Hierarchical Data Format Version 5 (HDF5)
Image Dimensions	1,000 rows x 1,000 columns
Data Dimensions	3 dimensional (D) Emissivity (values included for each TIR band) 2D all other bands
Data Layers	19 total in 7 Data Groups
Special DN values	-9999 for missing or cloudy data
Tile volume	~40 megabytes (MB)
Upper Left, Lower Right Bounds	(80°North, -171°West) (22°North, -54°West)

- Released February 2012
- Freely available

USGS

NASA

ASTER Applications



Thermal inertia (TI) derived from the ASTER data, which corresponds to a range of soil moisture from 9% to 25%. (a–g) The seven time periods detailed in this study. (h) The averaged image product of all seven image pairs showing the TI trend over time. Dry surfaces are more susceptible to wind erosion via sand saltation or dust emissions.

Univ. Pittsburgh, 2010.

Soil Moisture Monitoring

White Sands, NM

TIR

Low soil moisture indicates high dust storm potential

USGS

NASA

ASTER Applications

NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

Geologic Visualization

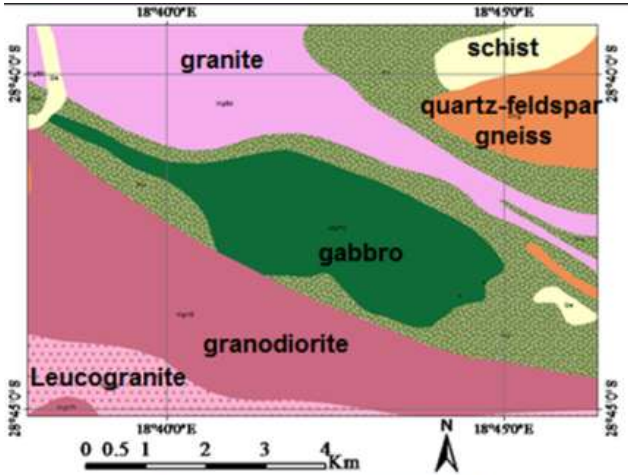
Kondyor Massif, Russia

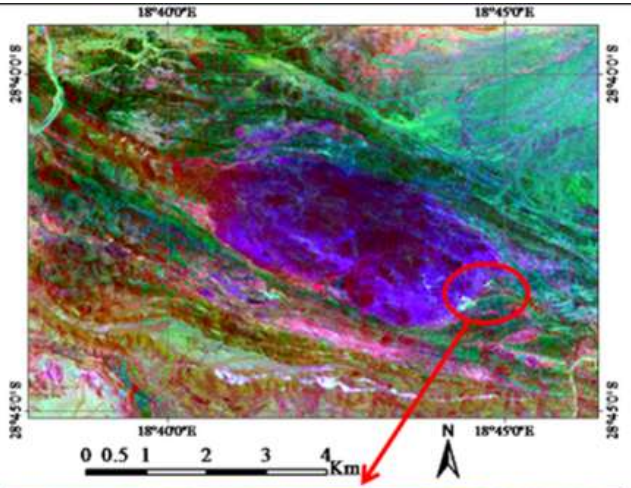
Simulated Natural Color Using VNIR Bands draped over DEM

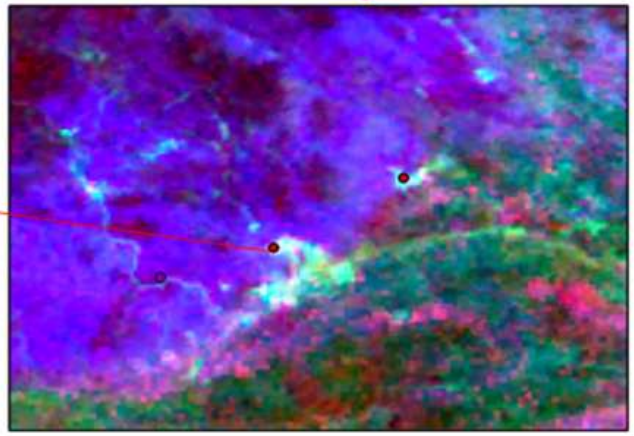
USGS

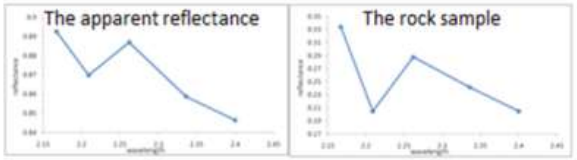
NASA

ASTER Applications









Uezato, Oshigami, Yamaguchi (Nagoya Univ.), Momose, Arvelyna, Kawakami, Yajima, Miyatake (JOGMEC), Nguno (G.S. Namibia) [AST June 2011]

Mineral Mapping

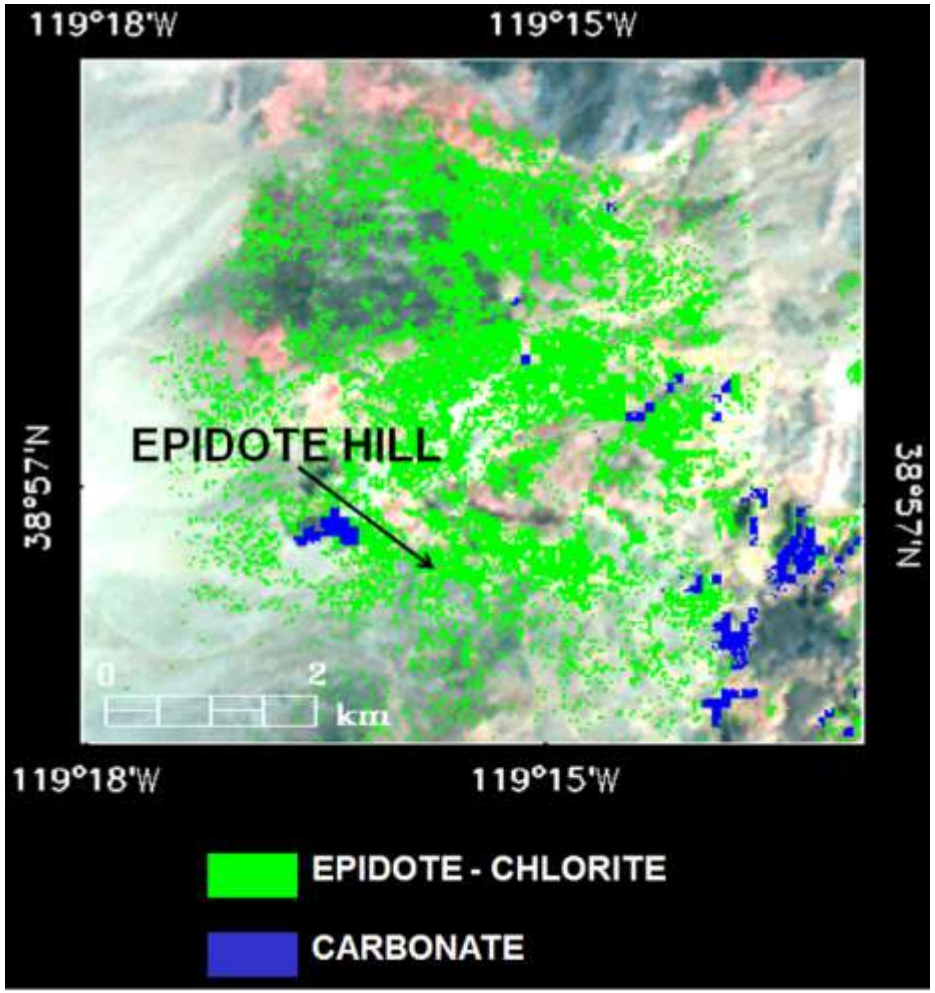
Southern Namibia

L1B

USGS

NASA

ASTER Applications



John C. Mars, USGS

Mineral Mapping

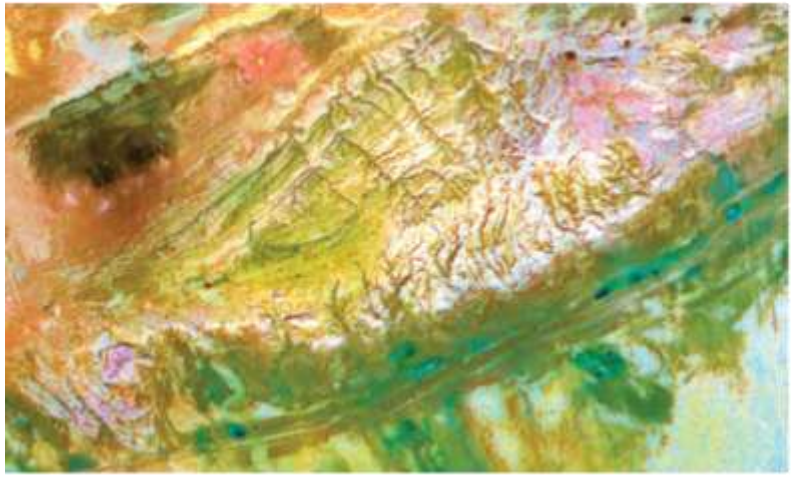
Yerington, Nevada

L1B

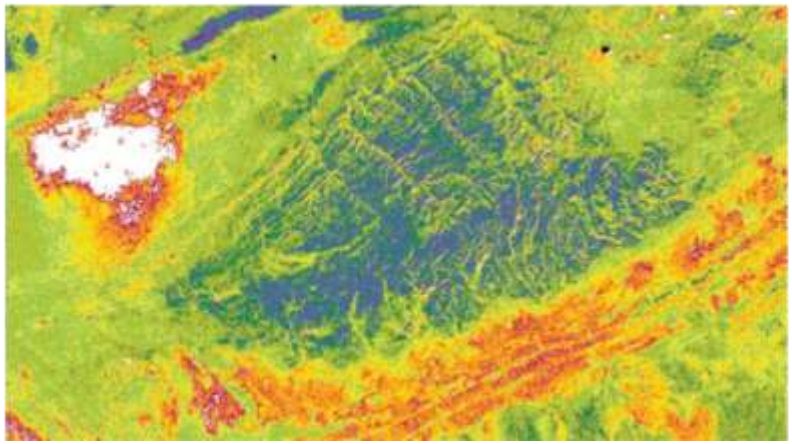
USGS

NASA

ASTER Applications



Band 631 color composite. "Best capability to map geological phenomena across whole peninsula. Red series appear as triangle in the centre, mud volcano deposits appear as pink areas" east and west of the Red series.



Band 1/ Band 2 ratio image. Lowest values in blue, highest values in red. Ability to map Red series using low values.

Junek (CTU Prague and Delft Univ. of Technology)

http://www.isprs.org/proceedings/XXXV/congress/comm4/papers/420.pdf

Geological Mapping Turkmenistan

Surface Reflectance

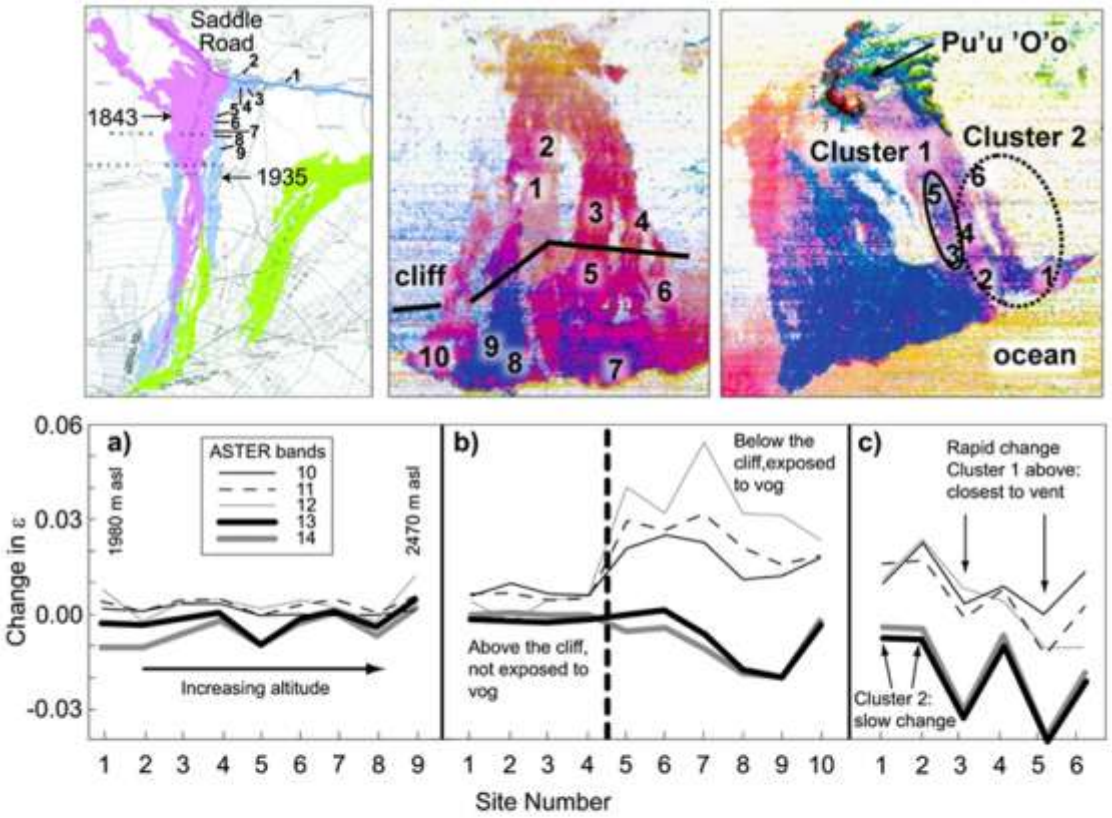
Pliocene Red Series Example

"promising results"

USGS

NASA

ASTER Applications



Spectral change in AST05 (2000-2002 minus 2007-2009) at three volcanoes. Mauna Loa, showing little change; Mauna Ulu, showing change only where exposed to vog; and Pu'u 'O'o showing change downwind from skylights.

Abbott, Gillespie, Kahle (IJRS publication)

Weathering and Alteration Change Detection on Basalt Flow Surfaces

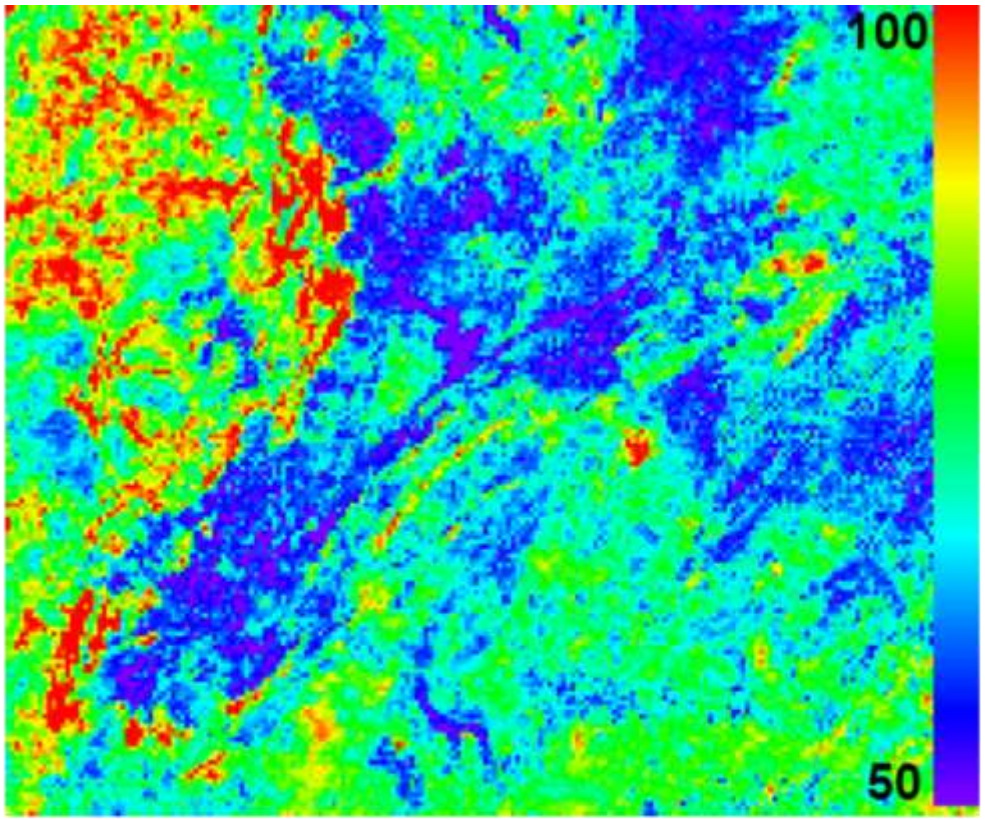
Hawaii

Surface Emissivity (TIR)

USGS

NASA

ASTER Applications



Silica content image. Purple: mafic rocks. Red: quartzose rocks. Color ramp represents SiO_2 weight % distribution.

Misra, Gupta, Sen (Indian Institute of Technology Roorkee). IEEE.

Mapping Lithology and Silica Abundance in Metamorphic Terrain

Northwest India

Surface Emissivity (TIR)

"The technique yields very close estimates of the true SiO_2 weight percent for the full range of lithology in the area."

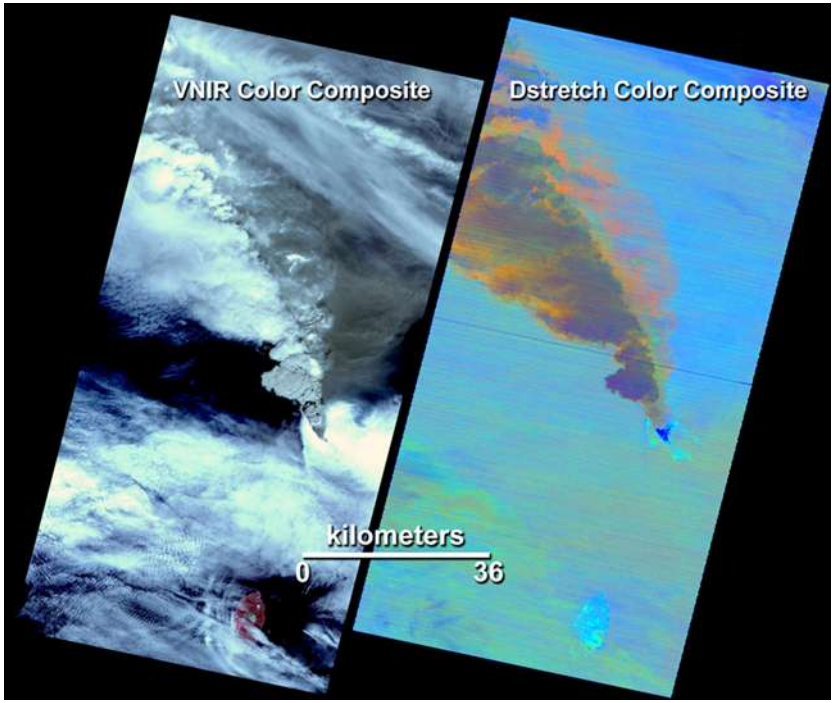
USGS

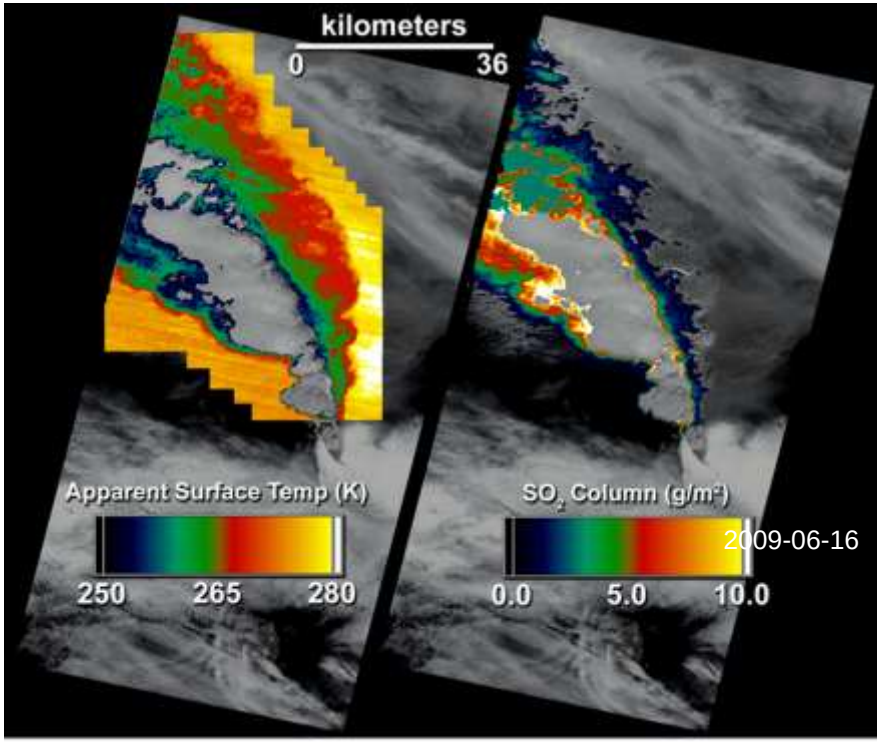
NASA

ASTER Applications

Mapping Volcanic Plumes

L1B TIR



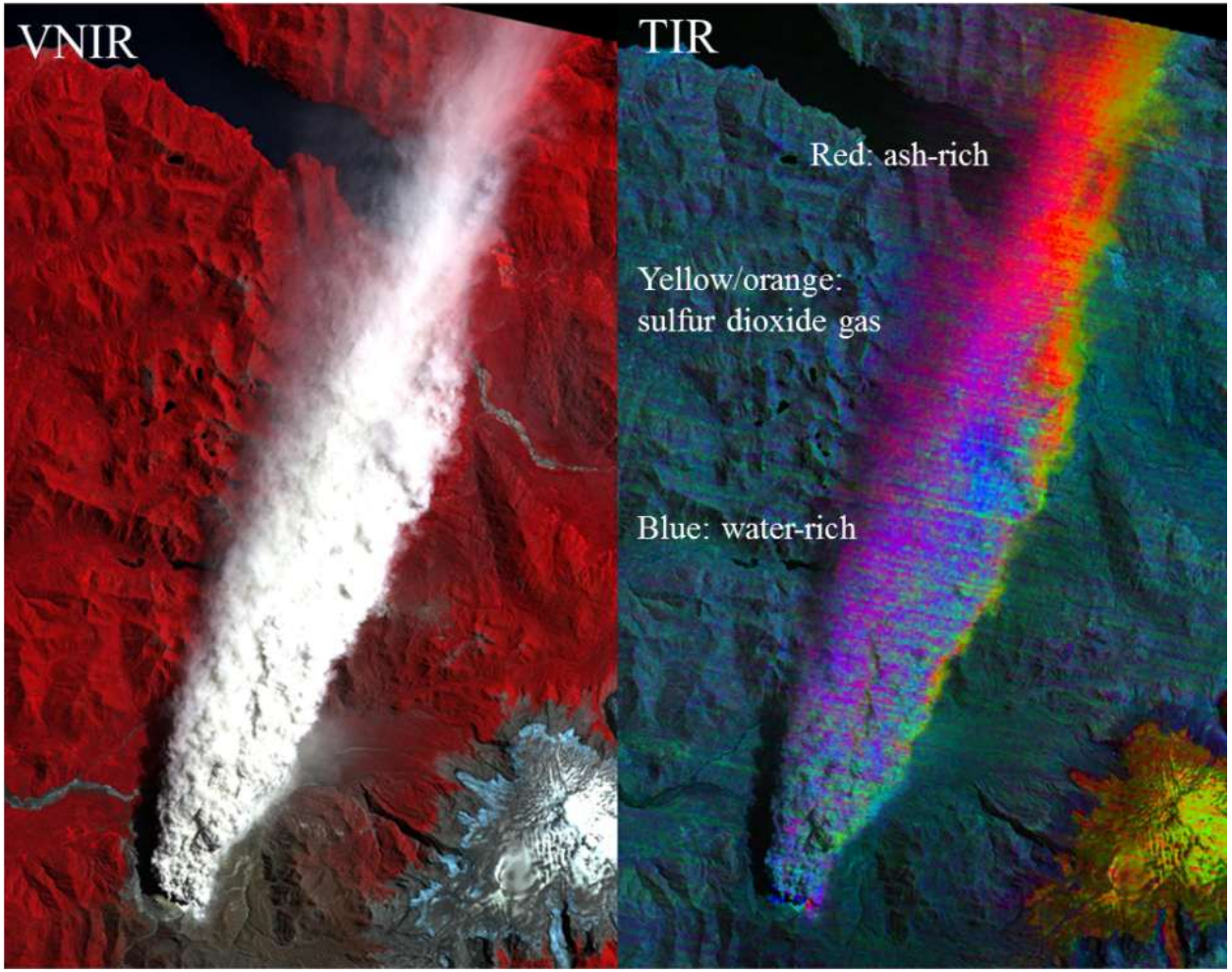


Realmuto (JPL), Baxter (JPL), Webley (Geophy. Instit./AVO UA-Fairbanks)

USGS

NASA

ASTER Applications



NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

Characterizing Volcanic Eruption

Chaiten Volcano, Chile

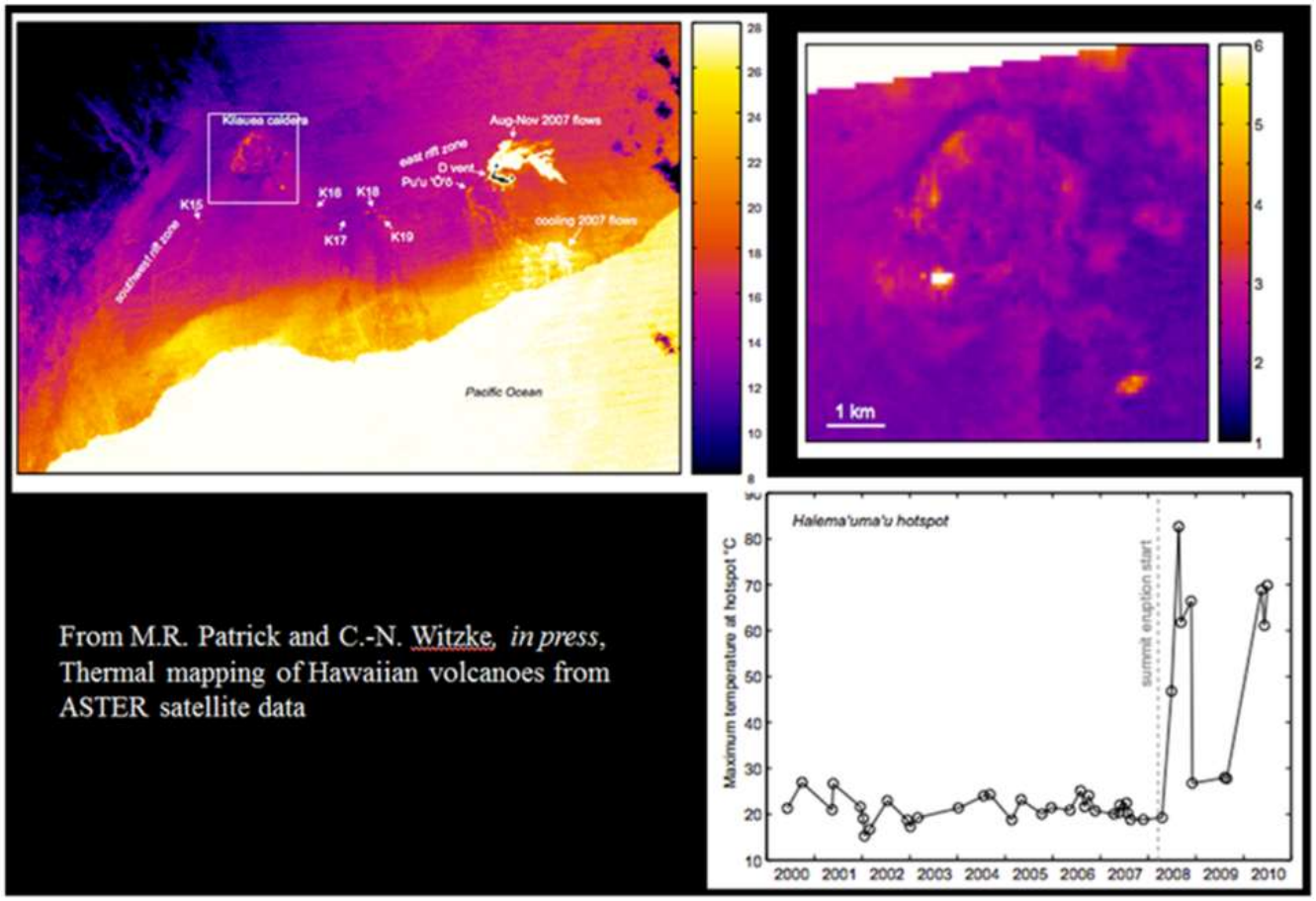
January 10, 2009

Expedited data

USGS

NASA

ASTER Applications



Volcano Monitoring

Hawaii

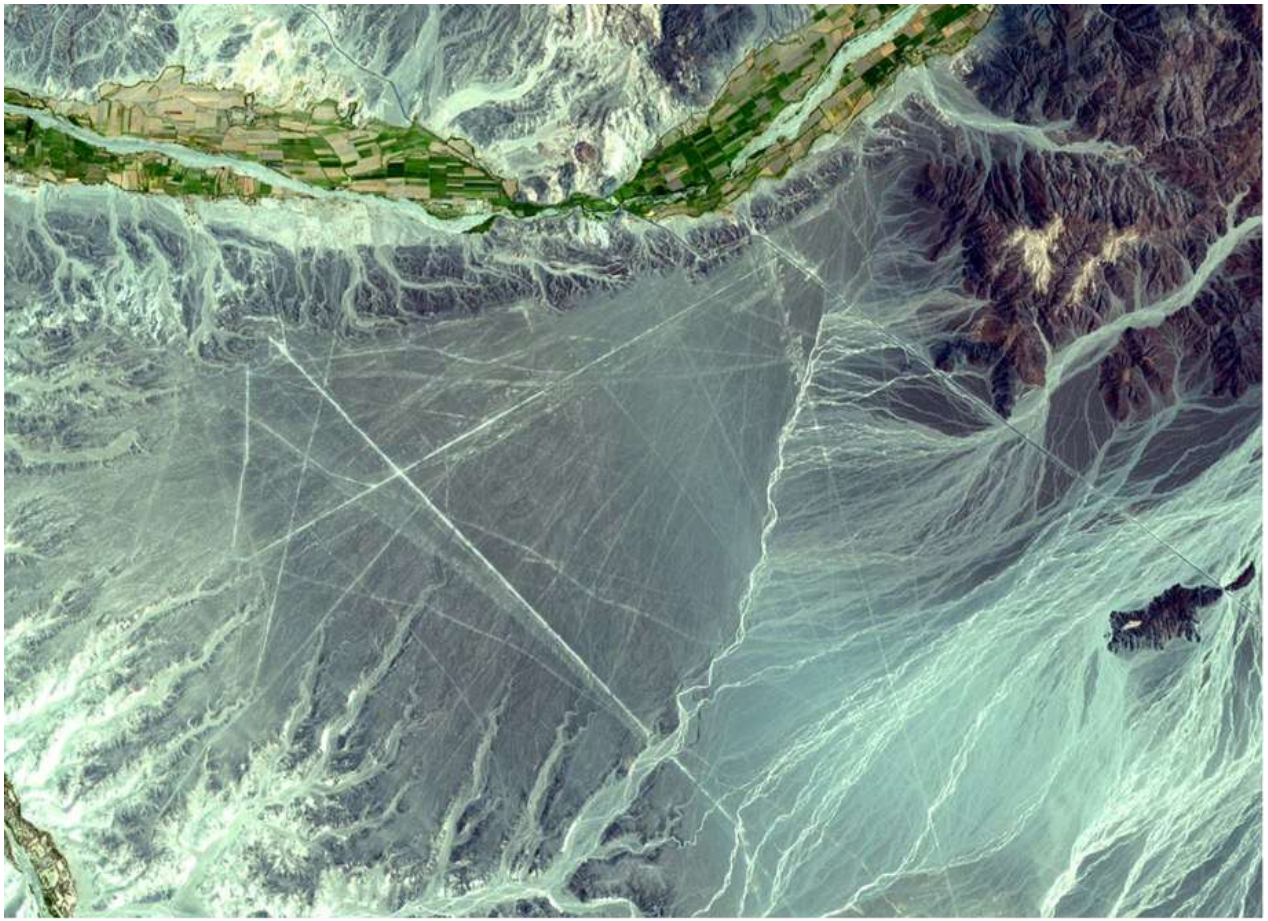
2000-2010

Surface Temperature

USGS

NASA

ASTER Applications



NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

Archaeology

Nazca Lines, Peru

Simulated Natural Color Using VNIR Bands

USGS

NASA

ASTER Applications

Urban Studies

Delhi, India

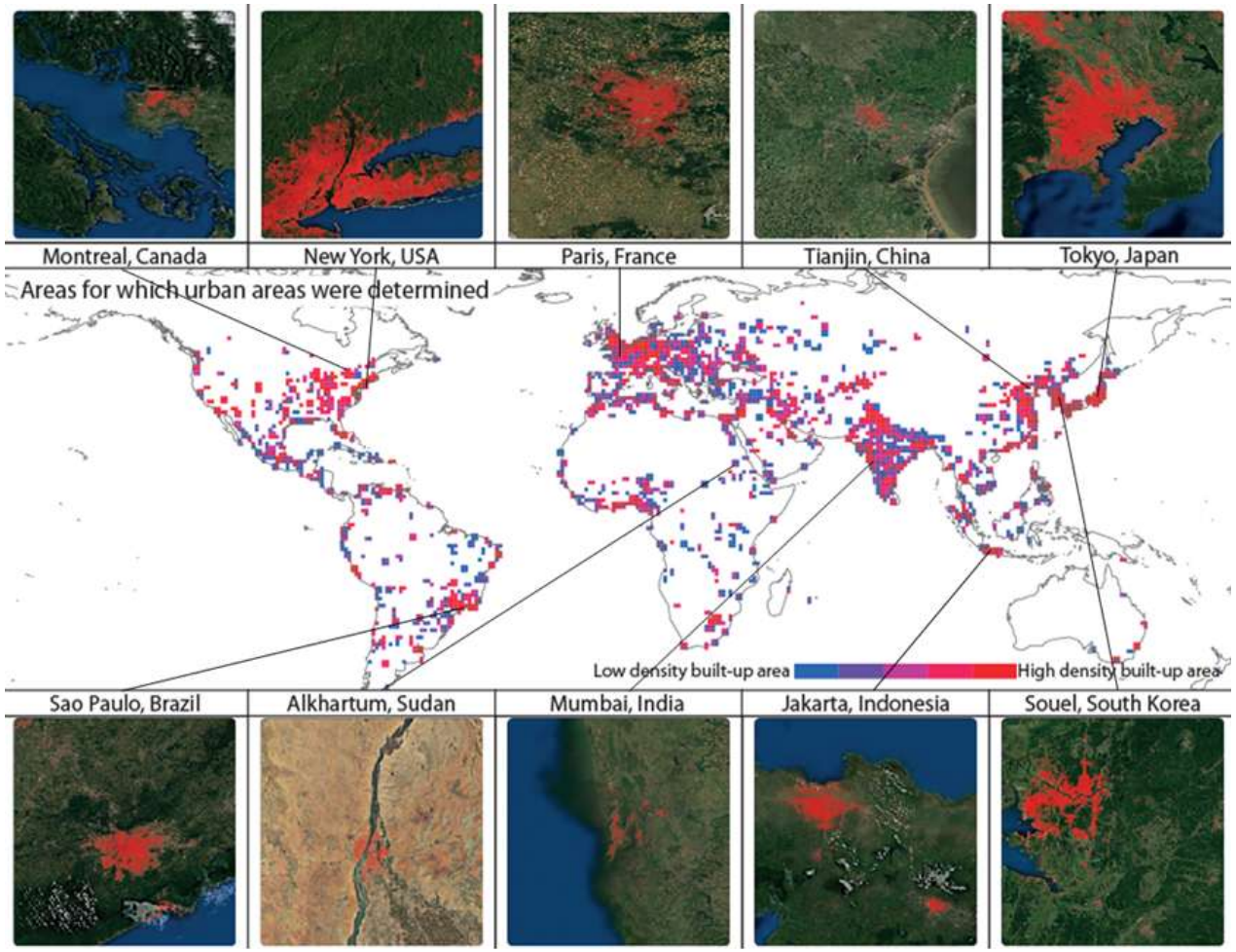
Simulated Natural Color Using VNIR Bands

NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

USGS

NASA

ASTER Applications



Miyazaki (Univ. Tokyo), Iwao (AIST), Shibaska (Univ. Tokyo)

Mapping Urban Extents

Global

3734 cities of more than 0.1 million population

15m resolution

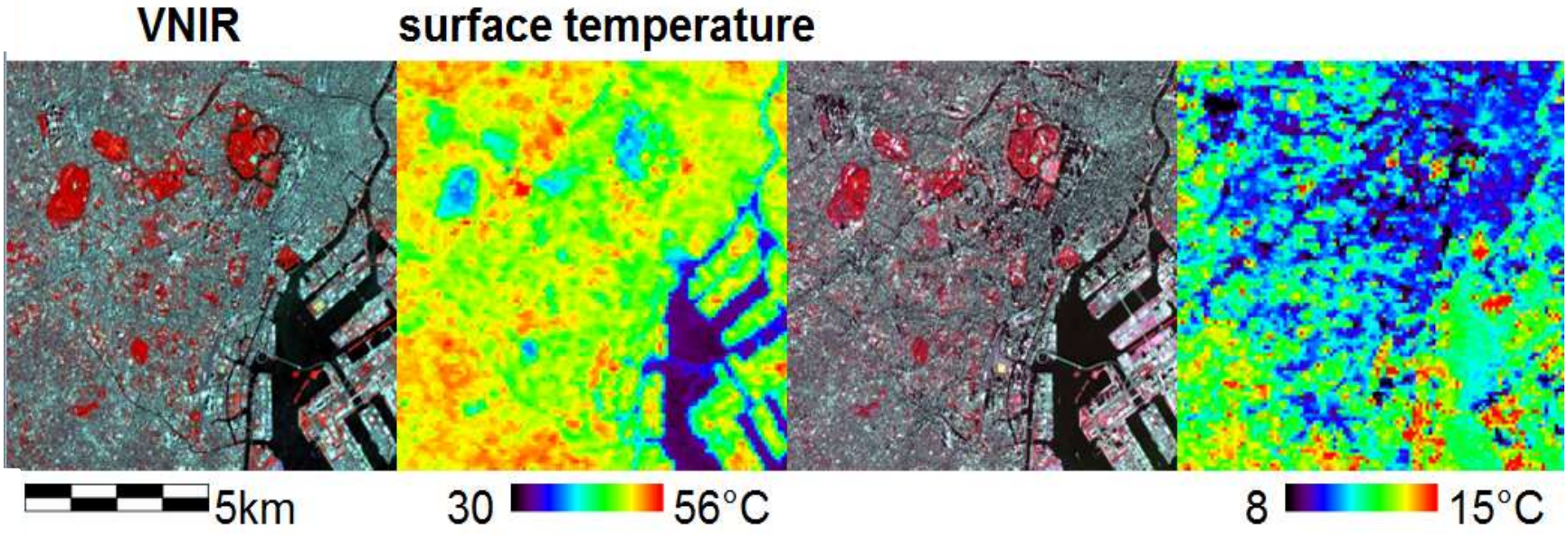
USGS

NASA

ASTER Applications

Monitoring Urban Temperatures

Tokyo, Japan (8/10/2002 & 1/17/2009)

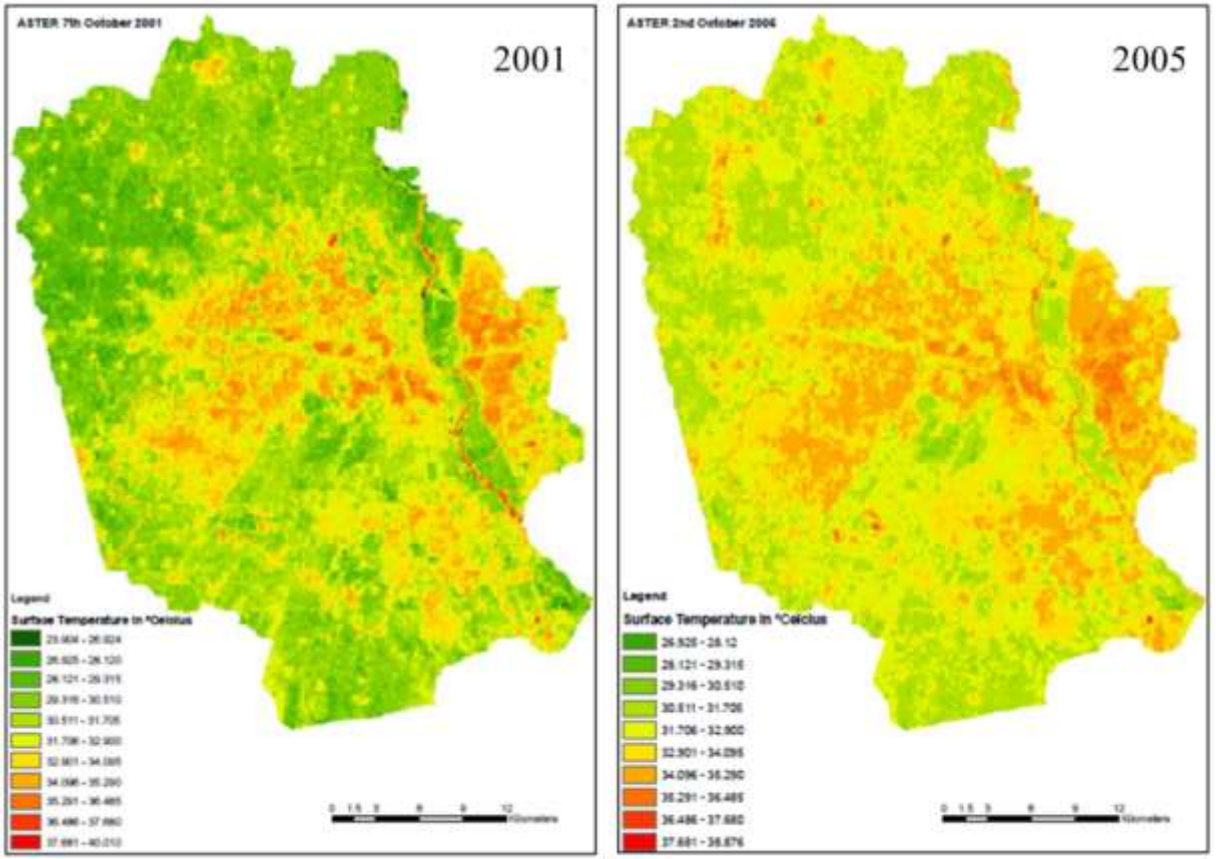


Kato, Matsunaga (Japan National Institute for Environmental Studies), Yamaguchi (Nagoya Univ.)

USGS

NASA

ASTER Applications

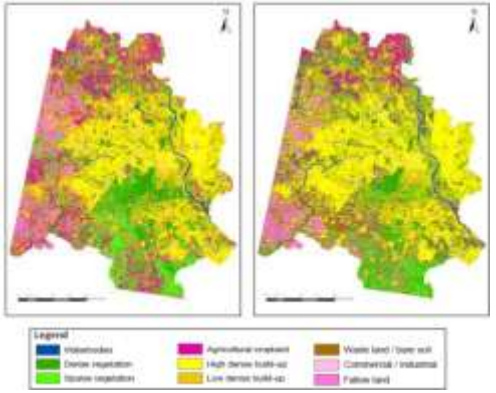


Mallick (India), Rahman (India), Hoa (Vietnam), Joshi (India). FIG Regional Conference, Hanoi, Vietnam, Oct. 2009

Urban Surface Temperature

Delhi, India

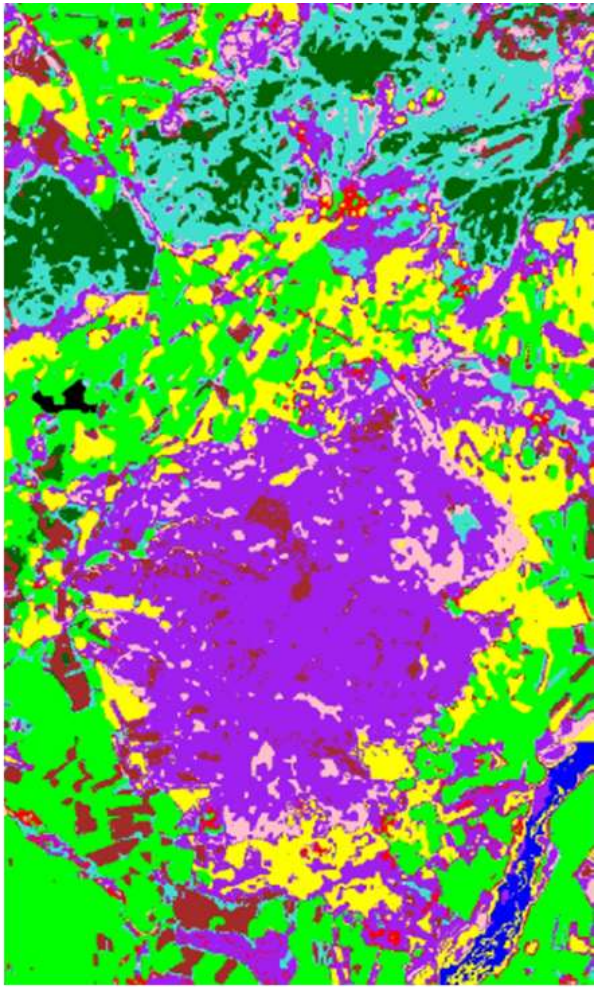
Night land surface temperature distribution combined with land use classification



USGS

NASA

ASTER Applications



Mapping Land Use & Land Cover
Kahramanmaras, Turkey
August 16, 2005

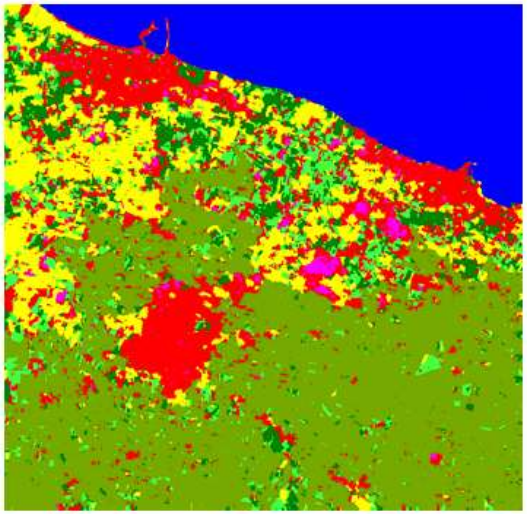
“accurate…and low-cost cover mapping”

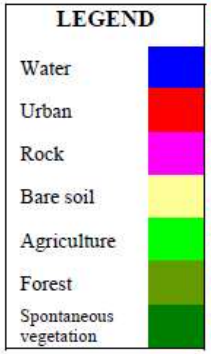
Yüksel, Akay, Gundogan (Kahramanmaras Suteu Imam Univ.)
Sensors 2008, 8, 1237-1251

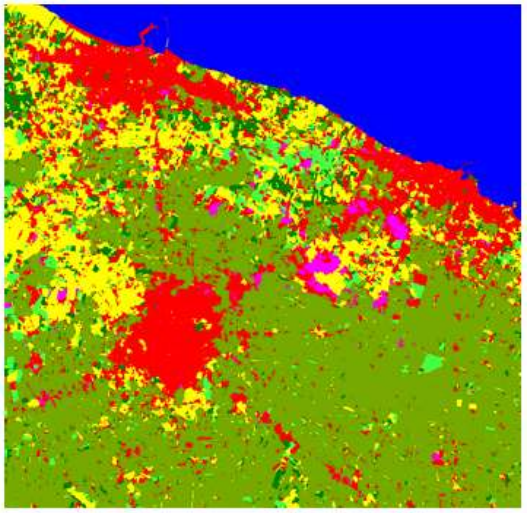
USGS

NASA

ASTER Applications







June 24, 2003

July 14, 2007

http://www.google.com/url?sa=t&rct=j&q=aster%20%22surface%20radiance%22%20applications&source=web&cd=24&ved=0CEcQFjADOBQ&url=http%3A%2F%2Fwww.mdpi.com%2F2072-4292%2F1%2F4%2F1171%2Fpdf&ei=C24YT7DTJaX_sQKB58DGCw&usg=AFQjCNF89uPM0CF3zPDyePklt_mckH5JeQ

Crocetto (Second Univ. of Naples) , Tarantino (Polytechnic Univ. of Bari) Remote Sens. 2009, 1, 1171-1189

Mapping Land Use & Land Cover Change

Italy

VNIR-SWIR for most classes, and TIR for Urban/Rock Discrimination

Overall classification result accuracy:

92.48% (2003)

92.84% (2007)

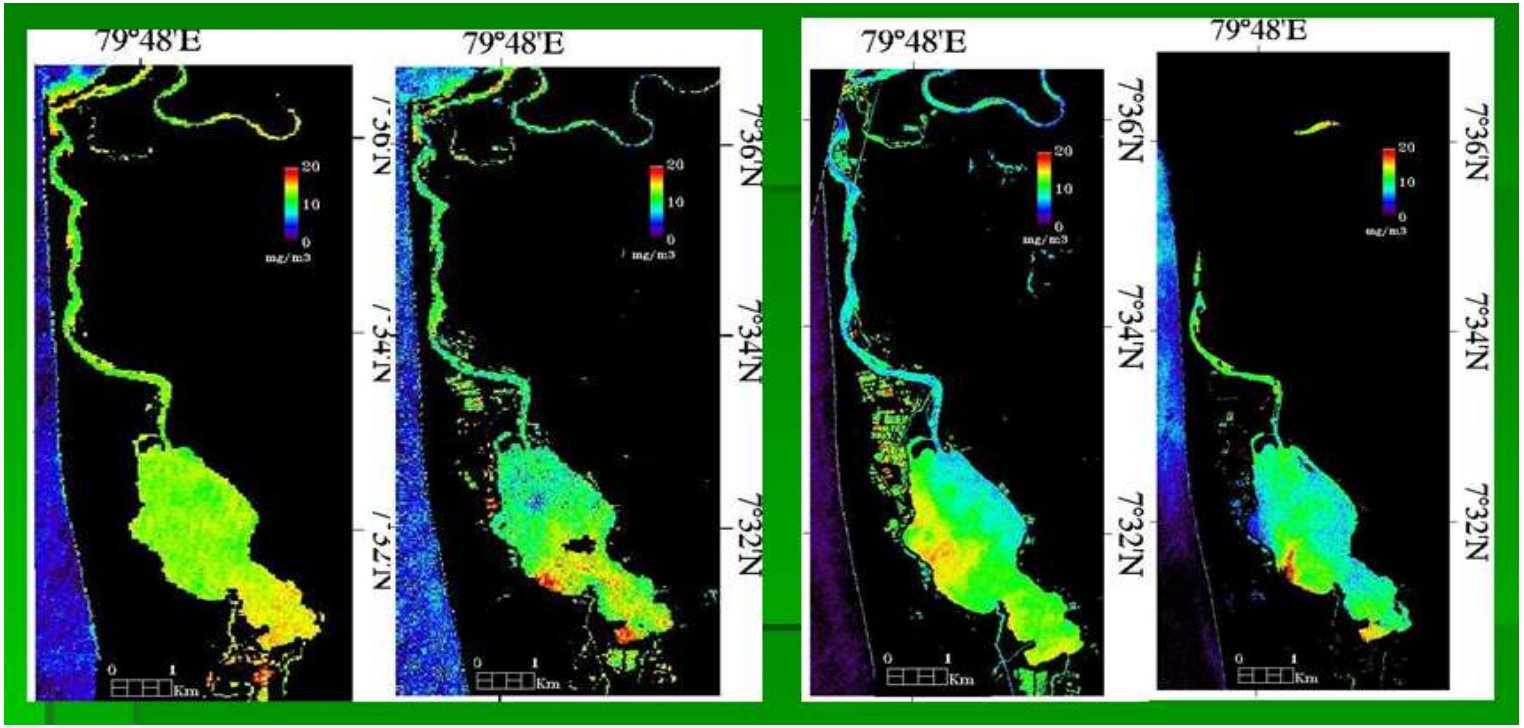
USGS

NASA

ASTER Applications

Monitoring Chlorophyll-a (Chl-a) Concentration

Sri Lanka, L1B



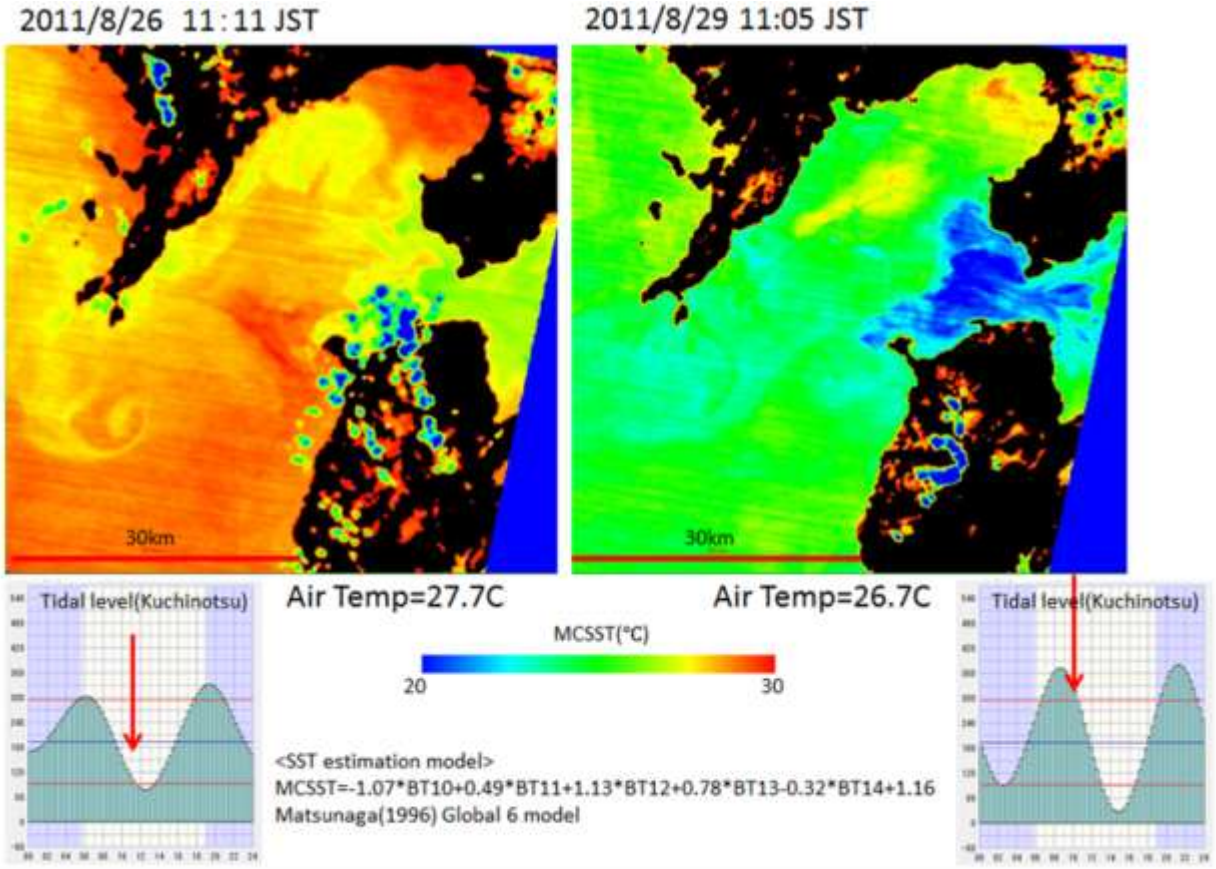
Examples of Chl-a maps derived from Landsat TM data (a) 1987.02.19 Landsat ETM+ data (b) 2000.12.15 and ASTER data (c) 2007.12.03 (d) 2011.02.13. ASTER VNIR B1/B2 used as Chl-a is positively correlated with green band reflectance and negatively correlated with red band reflectance.

Dahanayaka, Tonooka (Ibaraki Univ.)

USGS

NASA

ASTER Applications



Sakuno, Koike (Hiroshima Univ.)

Water Monitoring

Japan

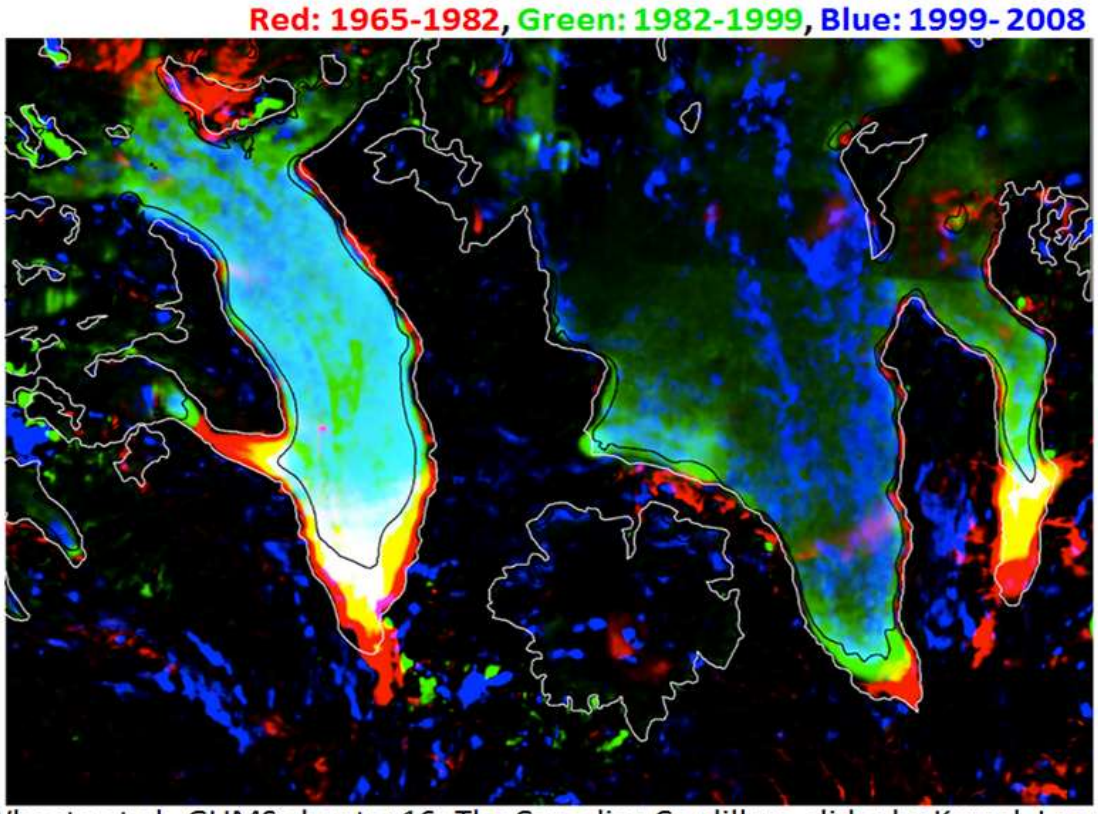
Surface Temperature

Red tide studies for impacts on fisheries

USGS

NASA

ASTER Applications



Wheate et al., GLIMS chapter 16: The Canadian Cordillera, slides by Kargel, Leonard, and Wheate

Global Land Ice Measurements from Space Science
Editors Kargel, Bishop, Kääb, Raup, Leonard

Glacier Change Detection

Canada

DEM

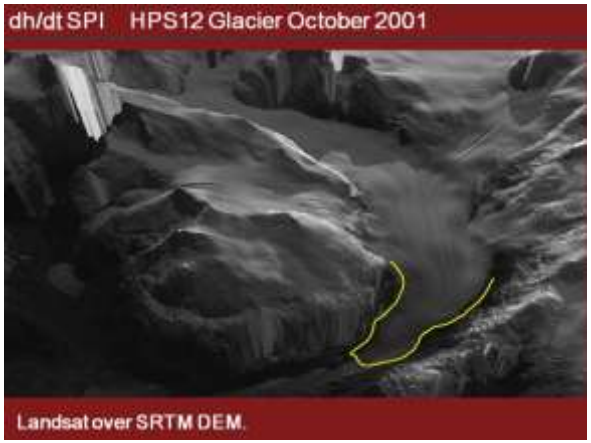
USGS

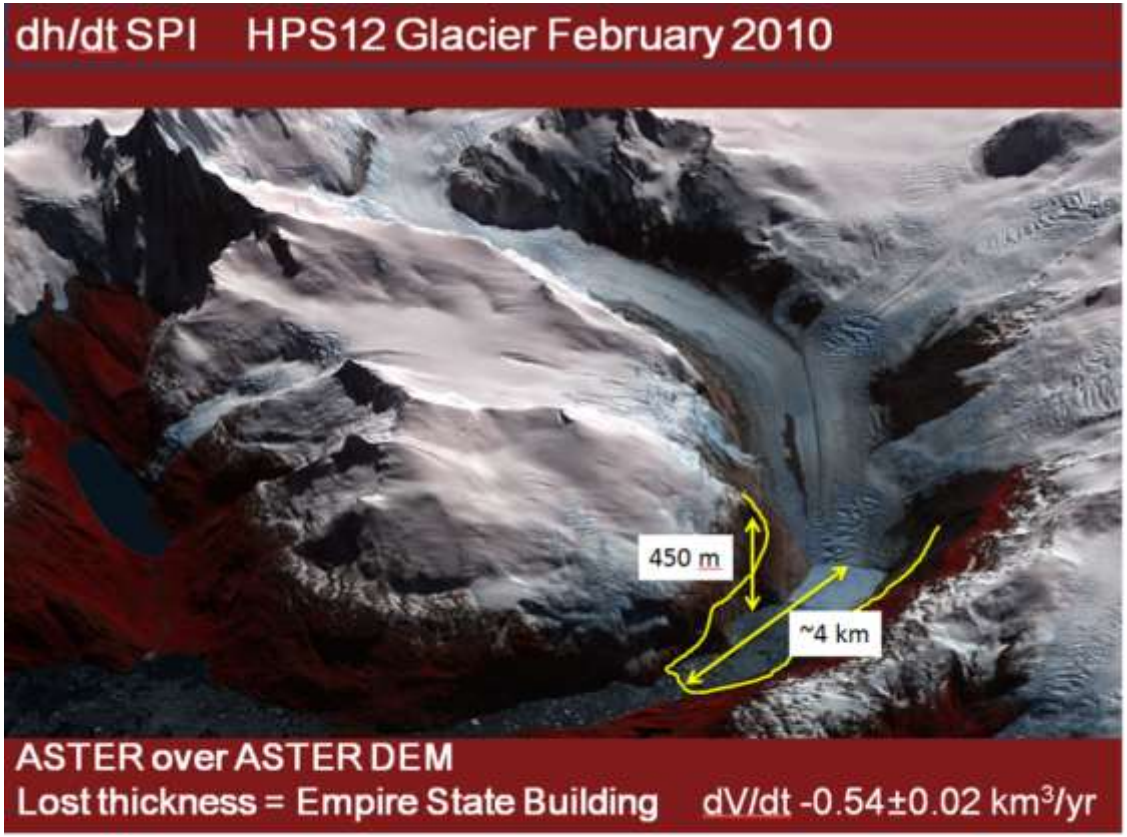
NASA

ASTER Applications

Mapping Glacier Retreat

Patagonia, South America



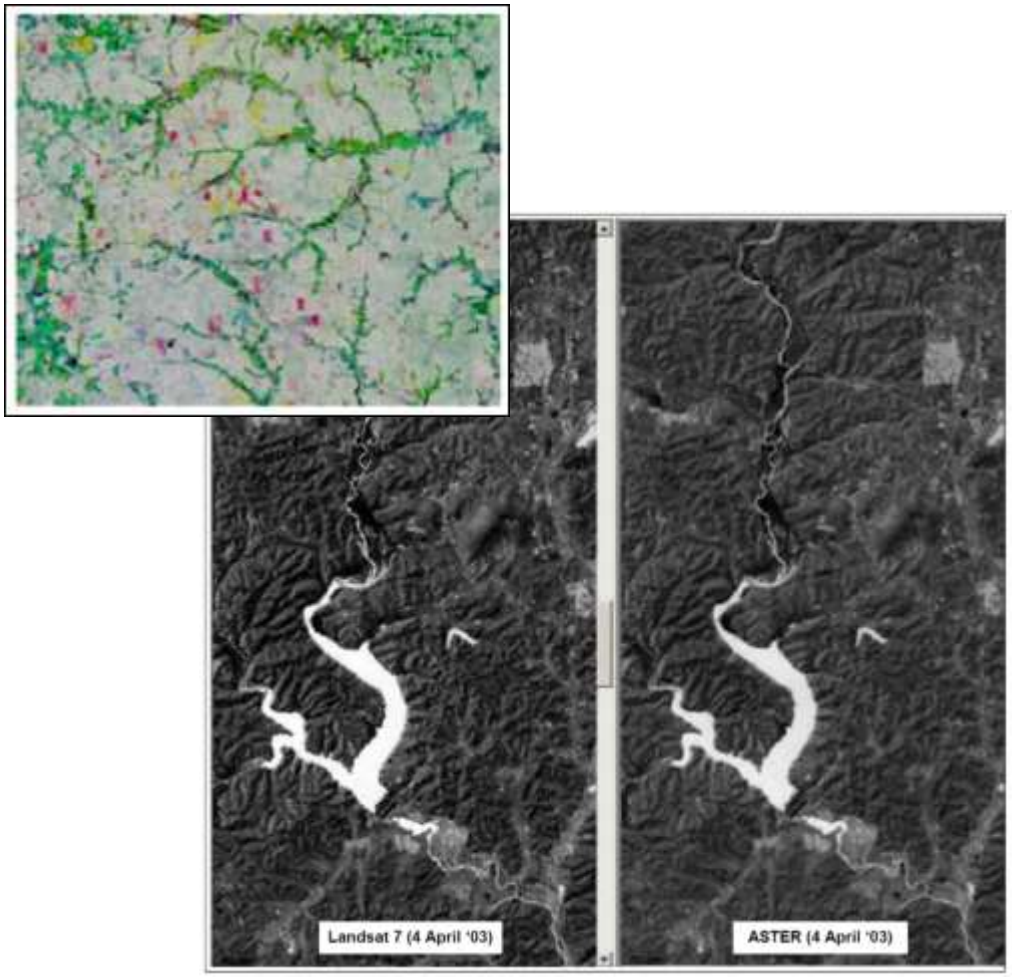


Willis, Melkonian, Pritchard (Cornell Univ.)
Ramage (Lehigh), Rivera (CECS), Ivins (JPL)

USGS

NASA

ASTER Applications



Maiersperger et al. 2006. Landsat-Calibrated ASTER Wetness Index. USFS. RSAC-76_RPT1.

Supplementing Landsat for Forest Monitoring

Ozark Highlands

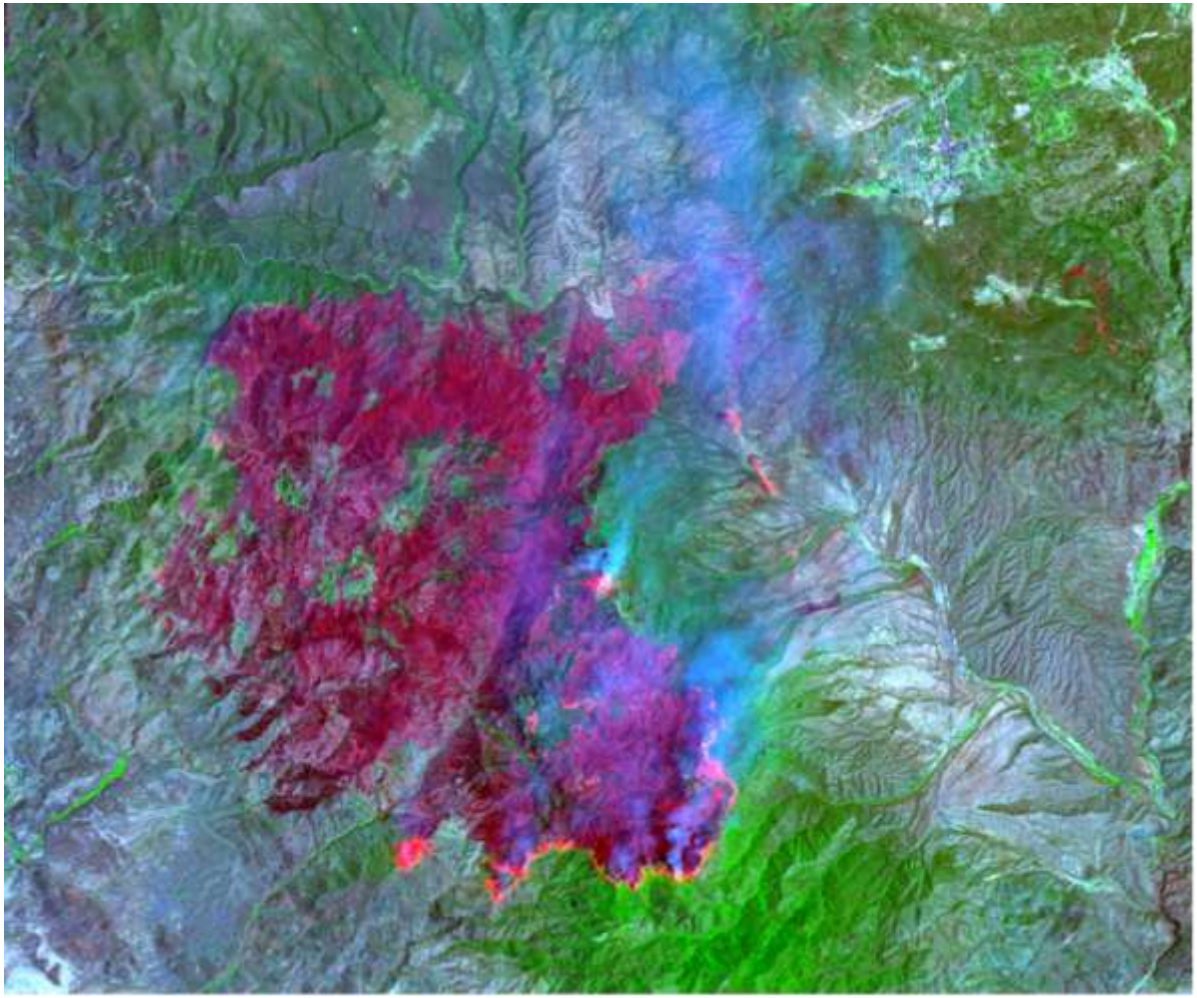
L1B

ASTER wetness index was derived and used in tandem with Landsat wetness to support change detection

USGS

NASA

ASTER Applications



NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

Wildfire Observation

Willow Fire, AZ

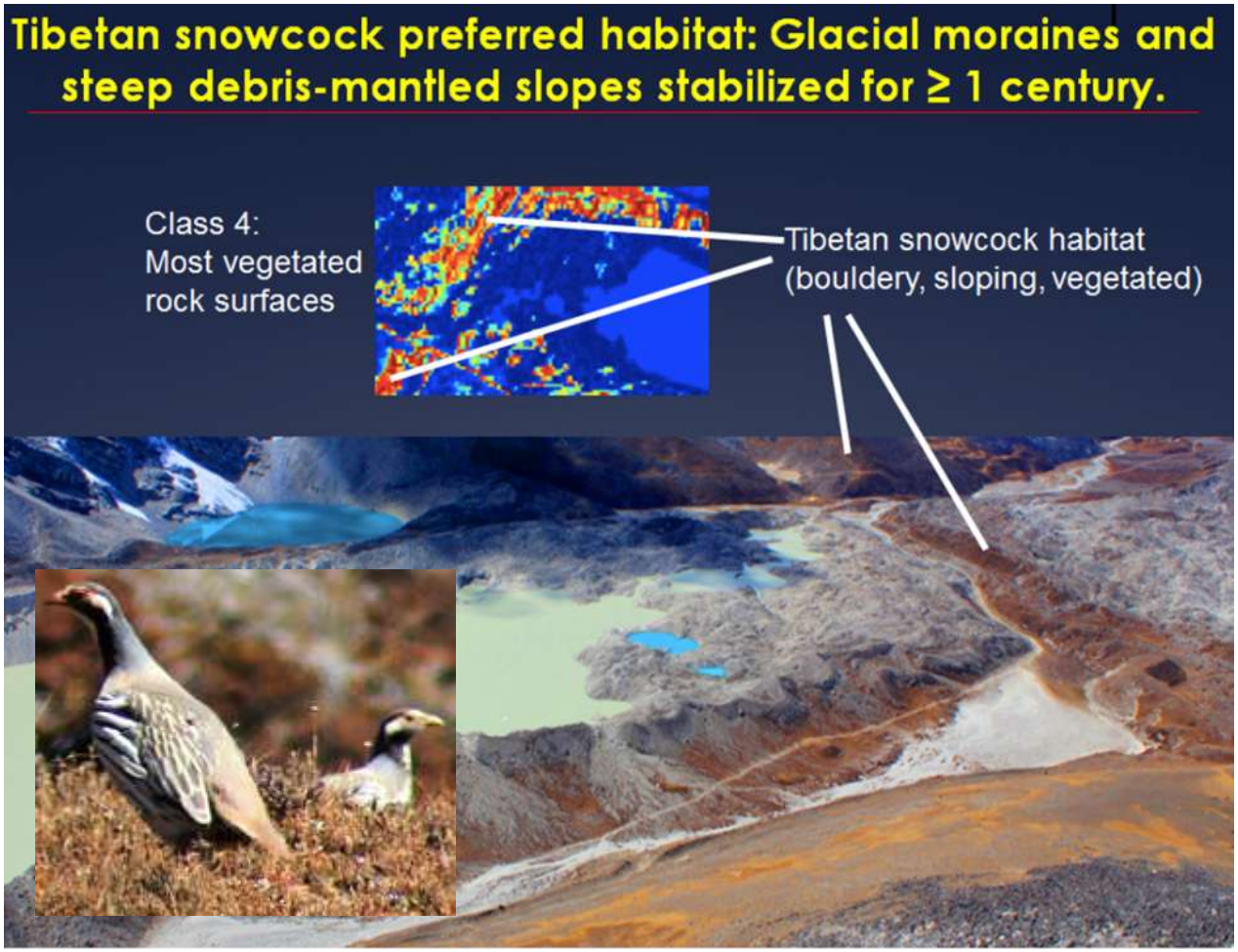
VNIR & SWIR composite

Fire fronts & burn scars

USGS

NASA

ASTER Applications



Kargel, Leonard, Furfaro (Univ. Arizona)

Habitat Mapping

Nepal

Unsupervised classification using both spectral information and topographic derivatives

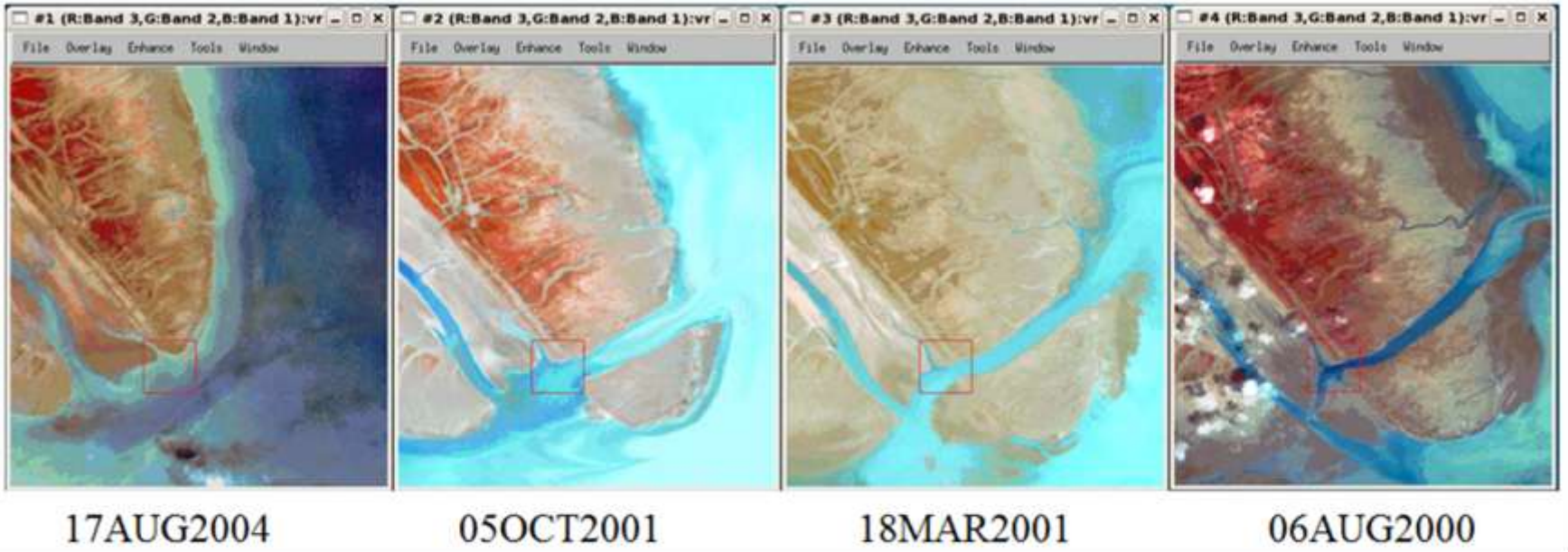
USGS

NASA

ASTER Applications

Monitoring Delta Changes

Yellow River, China (2000-2004)



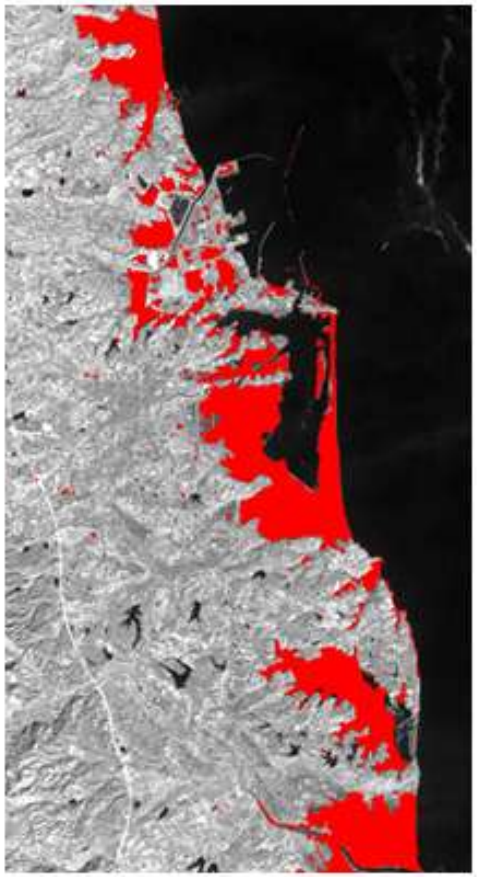
Time series DEM and orthorectified ASTER

Urai (Geological Survey of Japan, AIST)

USGS

NASA

ASTER Applications



ASTER

Map from air photo data

Urai, Minoru (Geological Survey of Japan, AIST)

Post - Tsunami Flood Detection

Japan

2011 Tohoku Earthquake

Method used pre- (May 1, 2007) and post-event (May 14, 2011) Band 3 ratio.

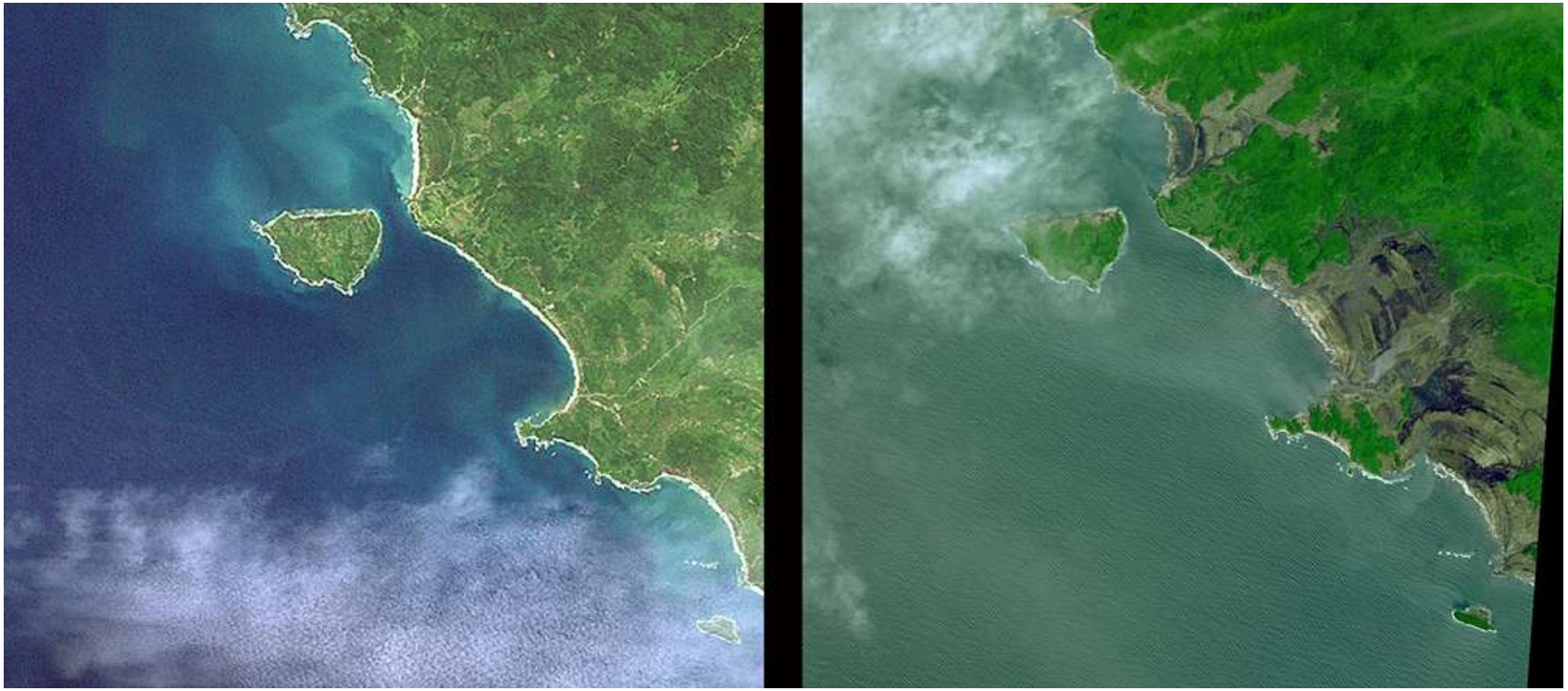
USGS

NASA

ASTER Applications

Detecting Coastal Impacts of Tsunami

Indonesia, Landsat and ASTER expedited data used in tandem



Landsat-7 June, 2001

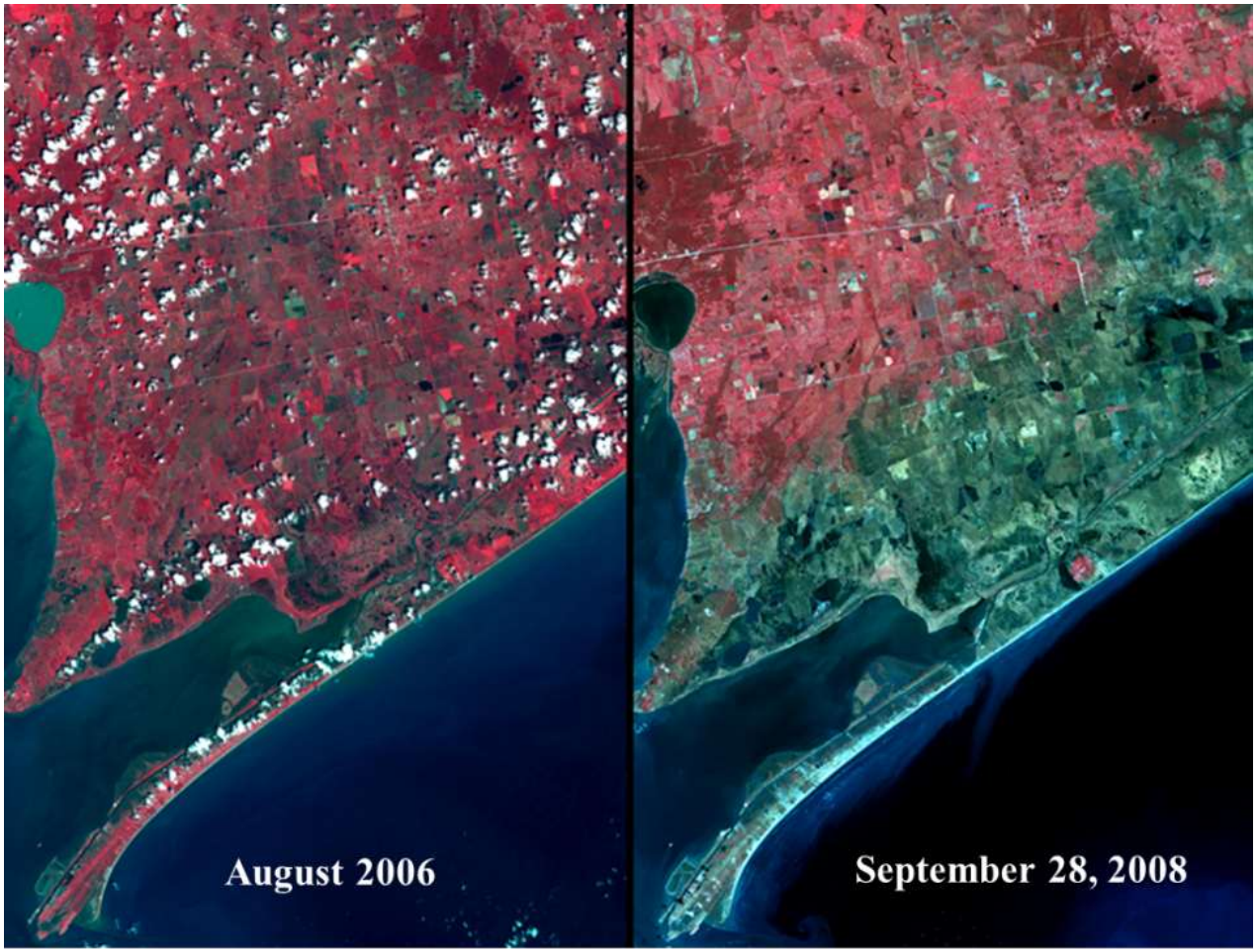
NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

ASTER simulated natural color. January 12, 2005

USGS

NASA

ASTER Applications



NASA, GSFC, METI, ERSDAC, JAROS, and U.S./Japan ASTER Science Team

Detecting Hurricane Impacts

Texas Coast, United States

Hurricane Ike Landfall

Sept. 13, 2008

Expedited data

VNIR composite

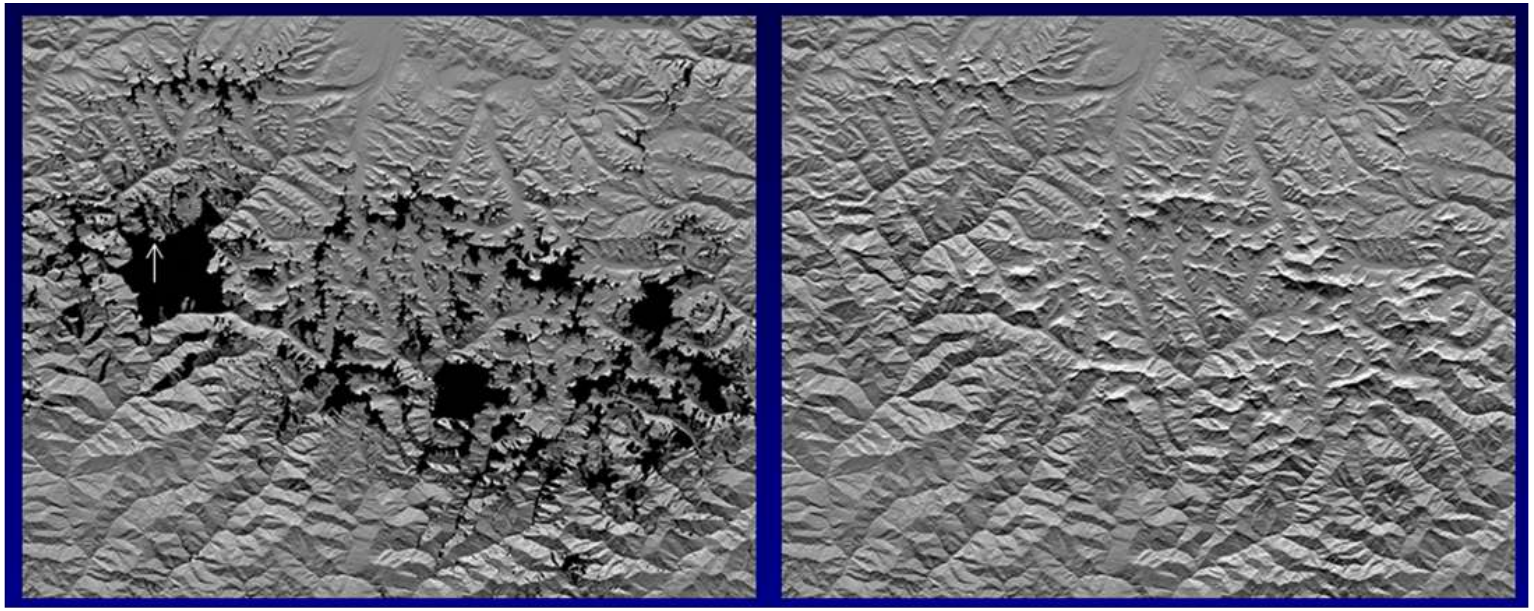
USGS

NASA

ASTER Applications

Filling Voids in Global Topographic Datasets

- **ASTER GDEM v2 to be used to fill voids in a new version of SRTM**
- **SRTM was used to fill voids in GDEM**



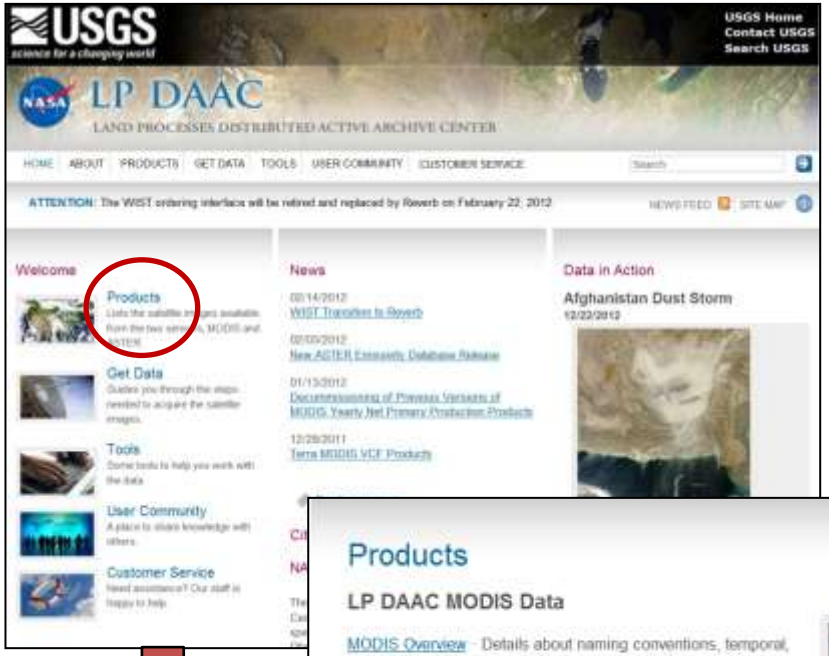
SRTM Himalaya Example GDEM v2

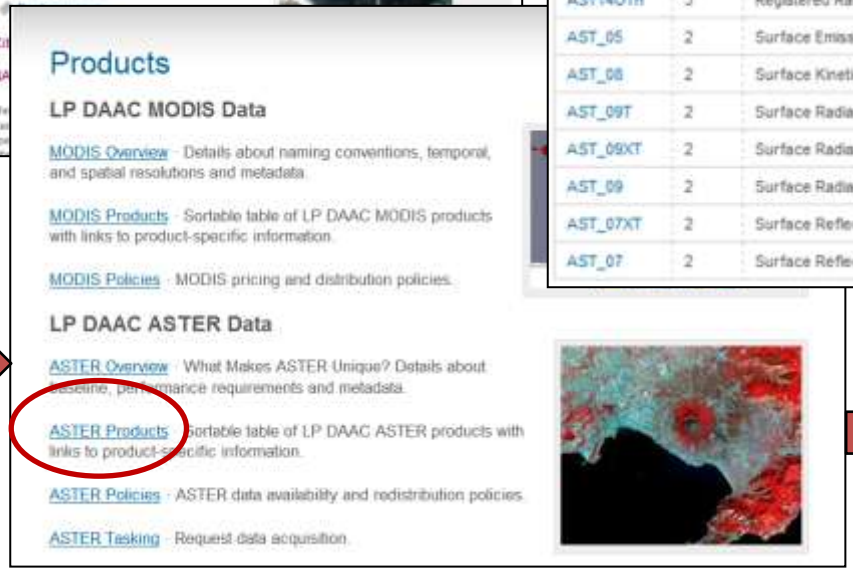
USGS

Crippen (JPL)

NASA

Additional Resources





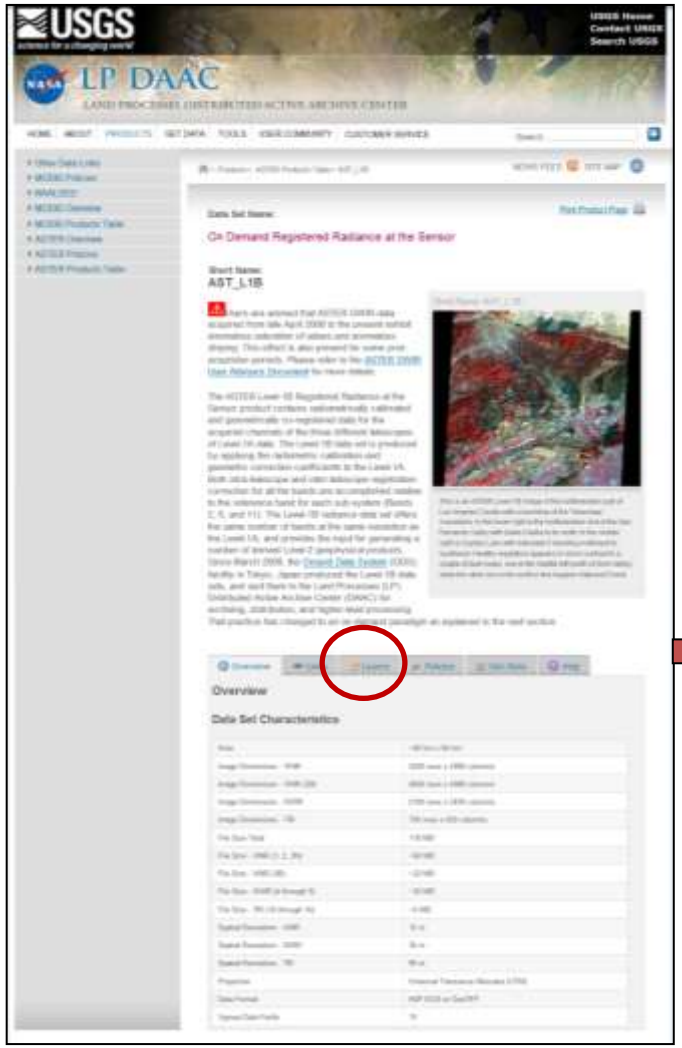
lpdaac.usgs.gov

Shortname	Level	ASTER Product	Res (m)
ASTGTM	3	ASTER Global Digital Elevation Model	30 grid
AST_L1A	1A	Reconstructed Unprocessed Instrument Data	15, 30, 90
AST_L1AE	1A	Reconstructed Unprocessed Instrument Data - Expedited	15, 30, 90
AST_L1BE	1B	Registered Radiance at the Sensor - Expedited	15, 30, 90
AST14DEM	3	Digital Elevation Model	30
[illegible]	3	Digital Elevation Model & Registered Radiance at the Sensor - Orthorectified	15, 30, 90
AST_L1B	1B	Registered Radiance at the Sensor	15, 30, 90
AST14OTH	3	Registered Radiance at the Sensor - Orthorectified	15, 30, 90
AST_05	2	Surface Emissivity	90
AST_08	2	Surface Kinetic Temperature	90
AST_09T	2	Surface Radiance TIR	90
AST_09XT	2	Surface Radiance - VNIR & Crosstalk Corrected SWIR	15, 30
AST_09	2	Surface Radiance - VNIR & SWIR	15, 30
AST_07XT	2	Surface Reflectance - VNIR & Crosstalk Corrected SWIR	15, 30
AST_07	2	Surface Reflectance - VNIR & SWIR	15, 30

USGS

NASA

ASTER Additional Resources



Overview | Links | Layers | Policies | Get Data | Help

Layers

VNIR (15 Meters) Rotation

Vgroup Data Fields/ Spectral Range (µm)	Units	Data Type	Valid Range	Telescope Pointing Capability
Band 1 (0.52–0.60)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-24
Band 2 (0.63–0.69)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-24
Band 3N (0.78–0.86)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-24
Band 3B (0.78–0.86)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-24

SWIR (30 Meters) Rotation

Vgroup Data Fields/ Spectral Range (µm)	Units	Data Type	Valid Range	Telescope Pointing Capability
Band 4 (1.600–1.700)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-8.55
Band 5 (2.145–2.185)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-8.55
Band 6 (2.185–2.225)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-8.55
Band 7 (2.235–2.285)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-8.55
Band 8 (2.295–2.365)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-8.55
Band 9 (2.360–2.430)	w/m2/sr/µm	8-bit unsigned integer	0–255	+/-8.55

TIR (90 Meters) Rotation

Vgroup Data Fields/ Spectral Range (µm)	Units	Data Type	Valid Range	Telescope Pointing Capability
Band 10 (8.125–8.475)	w/m2/sr/µm	16-bit unsigned integer	0–65535	+/-8.55
Band 11 (8.475–8.825)	w/m2/sr/µm	16-bit unsigned integer	0–65535	+/-8.55
Band 12 (8.925–9.275)	w/m2/sr/µm	16-bit unsigned integer	0–65535	+/-8.55
Band 13 (10.25–10.95)	w/m2/sr/µm	16-bit unsigned integer	0–65535	+/-8.55
Band 14 (10.95–11.65)	w/m2/sr/µm	16-bit unsigned integer	0–65535	+/-8.55

USGS

NASA

Questions?

USGS

NASA